The good education of youth has been esteemed by wise men in all ages as the surest foundation of the happiness both of private families and of commonwealths.—BENJAMIN FRANKLIN.

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SCHOOL SCIENCE
AND
MATHEMATICS

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A FIRST-DAY SUGGESTION FOR GENERAL MATHEMATICS

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That first day of school with its registration and adjustment problems can be made a most interesting and profitable one. A complete overview of the course, much motivation, and good instruction may result while the teacher is busy with the many problems of the day if the suggestions presented below are put into action. To get these results the teacher will have had to do much planning and working prior to the first day.

After assembling, the students are informed that they are to circulate about the room to observe and do as many of the interesting things as they can. The next day or days will be devoted to a discussion of what they have learned and of what they have tried to do or see. Those who have problems are urged to see the teacher whenever she is free.

In preparation for the class the instructor has set up displays which have written instructions or comments concerning them. In one corner, display one may be a mounted photograph of some famous building—for instance, a New England Church, labelled "An American Church." Three or four directives may be written below the photograph, such as

1. How much mathematics and what kinds were used in the construction of this building?
2. In what section of our country did this type of construction originate?
3. Find and list the six geometric figures used in this building.

4. Where do you see parallel lines, symmetry, a sphere?

Display number two may be captioned, "Do You Believe These?" On the table or eraser trough a paper napkin .003 of an inch thick is placed with the statement that if this napkin is doubled and then the doubled napkin is re-doubled, and this is continued for thirty-two times, there will be a pile of napkins over a hundred miles high. Do you believe it? This situation will result in considerable discussion and much computation. Will a fifty-cent piece go through the hole in this mimeograph paper which is the size of a quarter? Additional such "believe it or not" situations may be presented in this section.

On the next table might be a display of interesting books on mathematics with a label reading, "Have You Read Any of These Interesting Books?" Among the books should be *Fun with Figures*, by F. A. Collins, *Mathematical Wrinkles* and *Mathematical Nuts*, by S. I. Jones, *Flatland, by A. Square* (Edwin Abbott), *The Education of T. C. MITS*, *Non-Euclidean Geometry*, and *The Fourth Dimension* by H. G. Lieber and L. T. Lieber, and *Mathematics, Its Magic and Mastery*, by A. Bakst.

Display three might be a gallery of pictures and models, attractively arranged in a corner or on a table, labelled "Mathematics and Your Vocation." This would include photographs of navigators, farmers, engineers, lumber cruisers, architects, etc., using some phase of mathematics. Models of bridges, airplanes and other objects which require mathematics in their construction might be included. Specific applications of mathematics may be pointed out by arrows and printed comment.

On another table might be a collection of mathematical puzzles, tricks, stunts, and games, with the heading "Can You Figure These Out?" Cards upon which directions have been printed may be arranged about the table. One might state, "Can you construct four equilateral triangles—each side the length of a match—from the six matches lying in the adjacent space? Try it." After arranging the matches so you have I/VII in Roman numerals, change the position of one match creatin a situation equal to one."

Other cards might present problem situations such as "If it takes a hen and a half, a day and a half to lay an egg and a half, how long will it take thirteen hens to lay thirteen eggs?" Or, "How far does a chipmunk travel if he runs from one end to the other along the top of a log ten feet long and three feet in diameter while the log rolls down hill fifty feet?"

Another card may have this long division problem with the question:

```
        ELY
REAL | SPORTY
       LPPE
       ----
       CTTCT
       CTLPL
       -----
         ELRY
```

"What numbers do these letters represent?

What word will the ten consecutive digits spell?

Display five might be made up of problem situations affecting the non-technical citizen with the title, "Mathematics and You." Among the objects in the display may be an income tax form, insurance tables, graphs on the cost of living, longevity, etc.

On another table there could be a collection of mathematical tools: compasses, protractors, squares, etc., homemade and commercial. A sign above the table might read "Things to Do." Figures to be constructed, intriguing patterns to be copied, and other constructions might be listed.

In another section of the room under the caption, "Mathematical Models" could be a collection of crystals (wooden, cast, soap, or glass) of all forms. Other models should be included in this display.

Display nine might be titled, "What's Wrong with These Problems?" On the board could be placed one or more of the following: A problem all worked out with the right answer, but with an error in the computation. A problem could be presented with the wrong answer, or a geometric problem given in which one of the several premises is wrong.

Exhibit ten might be the bulletin board upon which could be posted poems, literary jewels, songs and jingles. "Mathematical Poetry" might caption the display. On this board may be a sign bearing this jingle:

> "If you plant cube roots in the ground, what grows?
> And where has a polygon, who knows?
> And where does an angle get its degree?
> And is it B.A. or Ph.D.?"

Another lettered sign bearing "A Song for Geometry" to the tune of "Maryland":

> "Oh geometry, geometry,
> A solid object, you'll agree,
> And what care I how plane it be,
> If it be not plain to me?

And angles; if your brain's acute,
Your work is right and sure to suit,
But if you chance to be obtuse,
To toil and weep is not much use."

There are many other poetic selections dealing with mathematics.

Students who are introduced to a new mathematics class in the suggested fashion outlined above will gain much knowledge of mathematics and at the same time will be challenged as well as pleasantly surprised. Their interest will be whetted, and they will look upon mathematics with a new light and enthusiasm as well as get an overview of what the course is to cover. Such an introduction can be most profitable.

Much of the course could readily develop out of these first-day activities. Some teachers have discovered this to be so. Others who have tried this type of an introduction have been disappointed. Further trials have resulted in happier outcomes. Mathematics teachers will do well to give the above suggested "Country Fair" idea a trial. With modifications the idea may be used just as effectively in geometry or algebra as in a general mathematics class.

THE JUNIOR COLLEGES ON MILITARY TRAINING

Junior college leaders, by more than a four-to-one vote, favor delaying decision on the question of adoption of a policy of universal military service until after the establishment of peace, according to a nationwide survey just completed by Walter C. Eells, Executive Secretary of the American Association of Junior Colleges. Replies were received from more than 750 junior college administrators and faculty members in over 200 junior colleges in all parts of the country.

By more than a nine-to-one vote, they favor the appointment of a widely representative National Commission to study the matter and make recommendations.

They are almost equally divided, however, on the wisdom of a peace-time policy of universal military service if a decision must be made now. On this question, 41 per cent of the colleges favored it, 44 per cent were opposed, and 15 per cent said they were uncertain.

If universal military training is to be adopted, however, they are strongly opposed to granting exemptions to any classes of young men, even to conscientious objectors. A majority favor a single period of 12 months devoted exclusively to military training without an effort to combine with it vocational training and general education and believe such a program should be entirely under the supervision of the armed forces.

A policy of universal military training would affect junior colleges particularly, since the great majority of their students are normally in the 18 to 20 year age group.

EARTH SCIENCE IN THE HIGH SCHOOLS

GEORGE A. THIEL
University of Minnesota, Minneapolis, Minnesota

Until a century ago science was general enough and simple enough so that no division was necessary. In fact, Huxley stated that "Science is nothing but trained and organized common sense." The basis of science is the belief that natural events have natural causes. However, it took man several thousand years to get any conception of the basic orderliness in nature. Prior to the time of Aristotle and Hippocrates, man seems never to have suspected that natural events might have natural causes, causes which he might discover and use in determining natural laws. Centuries later, after many natural laws were established, the field of science was called "Natural Philosophy." At the time of the 16th century Robert Boyle could have been classified as a physicist, physiologist, and mineralogist. In the 18th century, Charles Darwin could still be a naturalist with a rather thorough knowledge of biology, physiology, and geology; and James Dwight Dana, famous for his encyclopedic knowledge of minerals, wrote several specialized monographs on biological subjects.

Today, however, our knowledge of facts regarding natural phenomena has grown so great that we no longer attempt to include all physical science under one general designation, such as "Natural Philosophy." We now speak of various sciences: as astronomy, chemistry, geology and physics; and it is necessary to specialize narrowly if one hopes to become expert in any one field of physical science. However, the lines between these fields should not be sharply drawn, for they constitute a vast interrelated mass of orderly-arranged knowledge of natural phenomena.

During the early part of this century, each of the above branches of physical science was given some emphasis in the secondary school curricula and the high school graduate was at least introduced to some of the laws that govern his natural environment. During the past twenty-five years, however, the teaching of earth science in such courses as physical geography and physiography in the secondary schools has experienced a deplorable decline.

Since a knowledge of the processes acting on the earth has

such obvious and direct practical value, it is difficult to understand why, on any logical ground, it has been displaced. Even where the earth sciences have not been completely displaced, there is a tendency for them to be slighted. I refer to the many schools that now offer courses in general science. Most modern textbooks on general science contain a unit on earth science. In some that I have read, the subject is treated authoritatively and interestingly. However, if the general science teacher has had no training in any phase of earth science, that unit in the course is either passed over superficially or, in many cases, omitted entirely.

It is undoubtedly this apathetic attitude of the high school teachers toward earth science that is responsible for the gross ignorance displayed by many students in our college courses in which some knowledge of the earth is an assumed pre-requisite. Many instances could be cited, but the following are typical:

1. A student guessed that there were 120° of latitude between the equator and the north pole;

2. Looking at a large globe, a student wondered why the oceans did not run off at the south pole;

3. In a quiz in elementary geology, a student stated that the Rocky Mountains cross the Canadian Boundary in the State of Utah;

4. To my amazement, I found that a girl in my class did not know where her home state was located on a map of the United States. She was a graduate from a high school in a fairly large mid-western city and she entered college with a better than average College Aptitude Rating.

I agree with Dr. Carey Croneis, President of Beloit College, who, in the preface to his book "Down to Earth" stated:

"To us these are situations which seem paradoxical in the extreme. We find it just a little hard to understand man's intelligent and commendable interest in Arcturus, and the time it takes light to come from that distant star, when he seems to be abysmally ignorant of many facts concerning the planet from whose vantage point he scans the heavens. We are continually amazed that the students' familiarity with hydrogen, which he cannot see, and his apparent woeful ignorance of the hydrosphere, which he can see and feel and which is all about him. We are eternally surprised at the layman's relatively decent understanding of atoms, electrons, and genes, which he cannot directly observe, and his lack of knowledge concerning rocks,

minerals, and fossils, which he can not only see but can collect in his ordinary rambles in the out-of-doors."

You may argue that the high school curriculum cannot cover all the fundamental areas of human knowledge, and that you are attempting to prepare the students to discharge their common obligations as parents, workers, and citizens. I would answer that argument by stating that basic information about the earth will make them better citizens. The inborn curiosity and restless energy of adolescent boys and girls could be readily turned toward familiarity with the geologic materials along their daily paths. Such information would add to their future pleasure and profit, as well as to a deeper understanding of some of the problems of this industrialized society. It would provide the young students with an understanding of the varied aspects of the natural environment.

Teachers should bear in mind the fact that all out-of-doors activities of a life-time, no matter where spent, involve continuous contact with this natural environment. Never before has the average person had so wide an opportunity of coming into contact with the diverse aspects of nature as is afforded him today through our modern means of transportation. Scores of adults, after returning from vacation trips, have expressed to me their feeling of regret that they were not given an opportunity to learn something about earth processes while in high school.

For anyone who has studied physical geography or physiography, every river valley, gorge, meandering brook, cliff, lake shore, tidal marsh, and mountain peak has a degree of significance it never had before. The ability to interpret natural scenery properly depends on a knowledge of the forces which produced it. We may admire the beauty of a landscape or marvel at its grandeur, but we must know how it was formed before we can appreciate its full significance. A tourist standing at the brink of the Grand Canyon of the Colorado River sees an awe-inspiring chasm, glowing with color, breath-taking in immensity, and almost impenetrable to man. Simply as a spectacle, this great canyon thrills anyone who sees it. However, a student of earth science is not only thrilled by the spectacle, but he sees on a magnificant scale, the results of geologic processes that operate and are controlled by definite natural laws. He visualizes the changes that took place as each successive geological event transformed the region, until eventually it was elevated into the Colorado Plateau and sculptured by wind and stream erosion.

Man's home is on those portions of the earth that are above the level of the sea. He deals with geologic conditions in many of his activities and he would be greatly aided by understanding them better. He plows into weathered, surface rock materials and plants and cultivates his crops. With giant machines and dynamite, he cuts and grades his roads and railroads. He excavates foundation places for his skyscrapers, digs canals and tunnels. He sets up great plants in which to exploit the earth's mineral resources and to tap the energy stored as coal and oil. Yet how many of the millions of individuals employed in these enterprises ever studied anything about the earth on which they labor. How much greater would be their interest in their assigned task if they knew something of the history of the material that occupies their attention every day.

I am firmly convinced that some knowledge of the earth and its resources is of vital interest to every individual; for, after all, the earth furnishes three fundamentals to our very existence: plants, animals, and minerals. The science teachers in our secondary schools are the people charged with the responsibility of disseminating that knowledge. However, these teachers will not find an easy solution of the problem. The curricula of secondary schools are already crowded and not many geologists would consider it wise to introduce a regular course in geology at the secondary school level, even if it could be arranged. Many of us feel, however, that certain aspects of geology may profitably form part of a good course in general science. In many schools, field excursions for making and classifying geologic collections and for observing the results of geologic processes would be of greater educational value than the work now done in poorly equipped physical laboratories.

Needless to say, the teaching of earth science requires teachers with some systematic training in that area. A preliminary survey of the extent of college preparation in earth sciences by general science teachers now in the Upper Mississippi Valley region reveals that only 1.2% have had course work dealing with the physical features of the earth. Perhaps our high school graduates would know more about the earth as a whole if their teachers had been required to include some earth science in their college training.

Everything comes to him who hustles while he waits.—THOMAS EDISON.

PROJECTILES IN MINIATURE

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Much excellent material is available to aid the physics teacher in preparing demonstration experiments, for example Dr. Sutton's interesting book.[1] Many of the experiments suggested therein can be adapted to general pupil use in the laboratory; but many others require techniques too complicated to have them given into the hands of students. Many physics teachers are firm believers in the value of individual work in the laboratory, and are convinced that the scientific method of thought cannot be taught without it. It is with the hope that others may disclose some of their pet group experiments that the writer presents this material. The subject matter of this exercise has timely interest and value, especially in wartime, and has the further merit that it may be used at different levels. It may be used as a demonstration, as a non-mathematical exercise for general science, as a high school physics lesson involving elementary math, or as an extra-curricular project for the student of exceptional ability in high school. A thorough study of all the formulas involved requires the use of trigonometry, analytics, and elementary calculus so that the experiment may fit into some college courses.

Many of the laboratory exercises in use today in physics laboratories are somewhat standardized verifications of the laws of physics which are stated in the textbooks. While there is much to be said of the value of this type of work, its tendency is not toward developing leadership, originality, and independence of thought. With some individuals, and even some classes, it may be well to challenge the interest and ability of the pupil with material which is not cut and tried, and which partakes somewhat of the nature of research, in that there is no book available which will give the details of the project to the student. If he has to work it out himself, it is research as far as he is concerned. The theoretical work he does should be subject to experimental verification. Scientific methods of procedure and thought should be the goal, rather than any specific conclusion. The pupil should be "on his own" as much as possible, and

[1] Sutton, Richard Manliffe, *Demonstration Experiments in Physics*, McGraw-Hill Book Company, Inc., New York City, N. Y.

originality and resourcefulness should be appreciated and encouraged. If the project apparatus is simple enough to be made at home, and set up in a workshop or back yard, in various forms depending on the ingenuity of the individual, some real and lasting educational projects may be achieved. In some cases, such projects have developed into a hobby, and even into a life work. The by-products of this kind of learning are sometimes startling to those of us who have committed the sin of not expecting enough of students.

Projectiles and Trajectories

The study of projectiles and trajectories is a recognized part of the study of physics, and is mentioned in most high school and college physics texts. Little or nothing will be found in the usual laboratory manual along this line, because of the danger involved in the use of firearms, and the lack of suitable apparatus to fit the laboratory situation. The equipment herein described is simple, inexpensive, safe, and homemade. It makes the study of trajectories possible in any laboratory or even a home or backyard. The accompanying descriptive material is intended for teacher consumption, to be presented to the class by a blackboard lecture. If the work is to be used as a project for accelerated pupils, much of its value will be lost if the pupil is told to read the article. Instead the teacher should work along with the pupil, and endeavor to have the pupil work out the solution to his own difficulties, with suggestions from the teacher only when the pupil ceases to progress by himself.

As a demonstration, the equipment may be used to show the meaning of such expressions as trajectory, range, high-angle fire, parabola, and projected velocity. The fact that the range is greatest when the angle of elevation is 45 degrees may be discovered by experiment. It may also be shown that the same range may be attained using two different angles of elevation. Since the amount of energy imparted to the projectile on each shot can be made constant, the somewhat surprising constancy of the range in a series of shots may be shown.

Description of Apparatus

A simple form of the apparatus is shown in Fig. 1. This can be assembled from parts found in almost any physics laboratory. An advantage of using the right-angle clamps is that angles and directions can be easily adjusted and varied. Also

the "powder charge" or energy applied to the spring may be varied as desired, and then maintained at a constant value, by sliding the spring rod in its clamp, and then always stretching the spring clear down to the clamp before it is released. When the end of the spring is pulled down, it is held firmly against the clamp by a large screwdriver, which is snapped out of the way to release the spring. This should be practised a few times, to make sure that the proper technique is used. Proper release is obtained when the range of the projectile for several shots is constant.

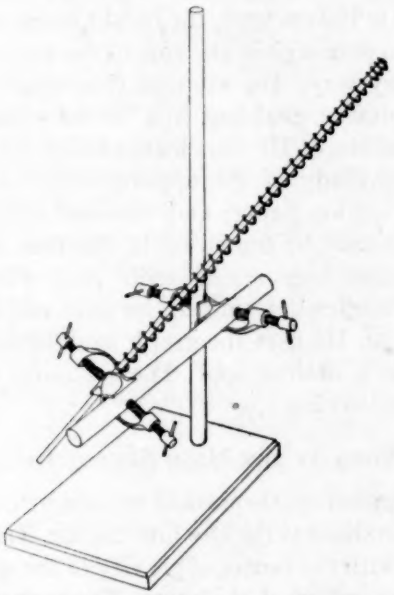

FIG. 1. Apparatus for projectile motion.

The "projectile" used is the spring from a discarded window shade roller. The wooden rod is cut open, and the spring taken out. All attachments to the spring are removed, until nothing is left except spring wire. It is sometimes necessary to bend over one end of the wire to close the end of the spring. The spring used in the series of experiments described here was about 10 inches in length, weighed 66 grams, and fitted loosely on a smooth $\frac{3}{8}$" rod. This rod was one meter in length, which is about right. Other lengths can be used, but for consistent results the spring must not be over-stretched.

No protractor was used with this gun, as it was considered more instructive as well as more accurate to use the sine or

tangent of the angle of departure. In some cases this will be the first introduction of the pupil to a table of sines, but with a concrete example of its use before him, the idea is usually grasped very quickly. A profitable discussion can arise as to whether or not it would be worth while to make a protractor, and if so how large it should be. Does the use of the sine tables permit as accurate a setting of the angle of elevation as a protractor would? How big would a protractor be which would give us the same accuracy as we get with say two meter sticks? Several factors, such as accurate centering and leveling of the protractor enter in here. If the rod is 100 cm long, the height in cm with the decimal moved over two places gives the sine of the angle in an accurate, simple, and easy way. The student thus meets the trig. table as a friendly device enabling him to do something quickly, easily, and accurately. He thus learns to use an important tool. Later on in his study of the apparatus, he may become acquainted with log-log paper, and the ease with which certain types of graphs may be drawn on it. He thus is introduced to another important engineering tool. And after his graph is drawn and his angles determined, he does not have something merely to look at. He uses the graph to determine how to land the projectile at a desired spot. The accuracy with which this can be done is satisfying.

Work at the High School Level

When the simplest mathematical treatment is desired, the gun may be set up to shoot vertically into the air. The end of the gun (do not bother with the center of gravity of the spring) should be 9 feet below the ceiling of the room. To measure this distance, lay off 9 feet on a window pole which will reach the ceiling. Now adjust the effective length of the spring rod so that the tip of the spring just touches the ceiling each time it is fired. The initial velocity of the spring is then equal to the final velocity attained when it falls 9 feet, which can easily be obtained from the formula

$$V^2 = 2gs = 64 \cdot 9$$

$$V = 8 \cdot 3 = 24 \text{ feet per second.}$$

Having determined the velocity of the projectile, we next calculate the range. In order to avoid trigonometry, the angle is made 45 degrees, and the range calculated from the formula

$$R=\frac{V^2}{g}=\frac{576}{32}=18 \text{ feet.}$$

The maximum height of the trajectory above the top of the spring rod will be only 4.5 feet, so this experiment can be performed in the average laboratory without the projectile striking the ceiling. Several shots should be fired, and the actual range measured. The percentage of error from the calculated range should be less than 2%. As a point of departure ten questions are included which have been used with various classes using this exercise.

QUESTIONS

1. Explain in words the principle used in calculating the initial velocity of the spring.
2. Show the arithmetic of this calculation.
3. How many gram-centimeters of work were done when the 66 gram spring fell nine feet?
4. How many gram cm of work were done in stretching the spring, assuming there was no friction?
5. Explain why you think the angle of elevation was 45 degrees exactly.
6. How much do you think we could be off in measuring this angle, giving definite figures.
7. What is the formula used in calculating the range?
8. Show calculations determining the range in feet.
9. What was the actual measured range of the gun in feet? How many inches would you say it varied?
10. What was the per cent of error of this experiment? Show work.
    What do you think was the main cause of this error?

A PRE-ENGINEERING PRESENTATION

It is to be hoped that more and more high school pupils will have had trigonometry and logarithms in their mathematics work before taking up the study of physics. If the students had this preparation, it would be possible to do a much better job of teaching physics. It is unfortunate that chemistry is taught in the senior year instead of physics, for the reason that these necessary mathematical subjects are usually taught in the senior classes. Logarithms are of little value in chemistry, and trigonometry is not used at all. But what a difference it would make in our physics work, if the pupils were proficient in these two skills!

Nevertheless if the students have not had this work, one need not despair. Trigonometry has been called the simplest branch of mathematics, and can be learned as needed in progressing through a physics course. It is no reflection on the teaching of mathematics to say that most physics teachers have to teach the practical use of mathematics to their classes anyway, whether pupils have "had" the courses or not. For example, in the experiment on "Resolution of Forces," it is easy to bring out that an inclined arrow V casts a horizontal shadow which is $V \cos a$, when the light is coming from above the arrow; and that the length of the shadow when the light is coming from the side is $V \sin a$. Using this concept as a point of departure, the formulas for projectiles can be developed on the blackboard so that a large percentage of the class will understand them, es-

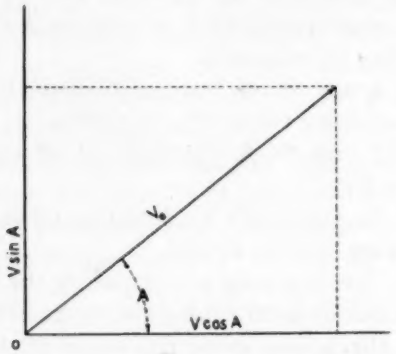

FIG. 2. Resolution of V_0 into forces at right angles to each other.

pecially if questions are asked and answered as the work progresses. The goal of the work is understanding; it is not expected that the student will learn to derive the formulas.

In beginning the derivation, draw the arrow V_0 as in Fig. 2, which represents vectorially the initial velocity and path of the projectile. Assume that there is an automobile on the ground, which moves so that it always stays directly under the projectile, as it passes through the air. If the class is asked what the velocity of the car is, everyone usually answers in chorus, $V_0 \cos a$. And so it is apparent that the horizontal velocity of the projectile, x, is also $V_0 \cos a$. Next assume that a helicopter rises straight up from the ground at such a rate that it stays level with the projectile. If asked what the rate of rise of the helicopter is, many will feel sure that it is $V_0 \sin a$, but it is not so. It

will be astonishing to many in the class to learn that the projectile starts to fall just as soon as it leaves the gun barrel! Of course it is still going up, but every second it loses as much velocity as it would have gained in freely falling for that second. Hence we must subtract this velocity, gt, from the vertical component of its original velocity V_0 and we get

$$V_y = V_0 \sin a - gt.$$

Now V_y keeps decreasing as the projectile rises, until when it reaches its highest point, V_y will be zero and

$$V_0 \sin a = gt \quad \text{or}$$

$$t_1 = \frac{V_0 \sin a}{g}$$

where t_1 represents half the total time of flight. The whole time of flight T would be $2t_1$ and

$$T = \frac{2V_0 \sin a}{g}$$

while the entire distance covered before the projectile hits the ground, usually called range, would be

$$R = V_x T = \frac{2V_0 \cos a V_0 \sin a}{g} = \frac{V_0^2 \sin 2a}{g}$$

since the trigonometry books prove that $\sin 2x = 2 \sin x \cos x$.

It is usually important to know what the maximum height will be. We will abbreviate this by calling it Y_{max}. We can find this easily because we know that Y_{max} is equal to the average vertical velocity, multiplied by the time of $\frac{1}{2}$ flight, which we have called t_1. Since the projectile gradually slows down and stops, its average velocity is $\frac{1}{2}v_0 \sin a$. So the distance Y_{max} will be $v_{av}.t_1$ or $\frac{1}{2}v_0 \sin a$ multiplied by $\frac{v_0 \sin a}{g}$ which gives us $\frac{v^2 \sin^2 a}{2g}$. These two formulae, for range and for maximum height, are the only ones which are important enough to derive. Complete formulae and derivations may be found in the physics text used at Annapolis.[2]

Next draw a circle on the blackboard, and sketch in different angles as shown in Fig. 3. Assuming the radius is 1, it is plain

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[2] Hausmann and Slack, *Physics*, U.S. Naval Institute Edition, D. Von Nostrand, New York, N.Y.

that the sine can never be more than one, and that this will occur only when the angle is 90 degrees. However in our formula for range, the sine will be 1 when the angle is 45 degrees, because we are dealing with the angle $2a$ instead of a. Most of the class

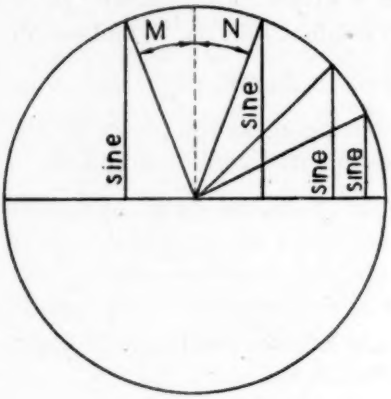

FIG. 3. Sine values.

will already know that the maximum range occurs when the angle is near 45 degrees, and will appreciate the aptness of the formula. It is then clear that if the angle is 45 degrees, $2a$ is 90 degrees, and the expression sin $2a$ becomes unity, and the range is simply V^2/g. Fig. 3 also shows that the sine of 90 plus 10, or M is the same as the sine of 90 minus 10, or N, so that the range of the gun at 35 degrees is the same as the range at 55 degrees. This can be verified experimentally, although unless a small "powder charge" is used, it may be necessary for the class to adjourn to a gymnasium or auditorium with a high ceiling, for obvious reasons. Interested students may look up and explain to the class the types of artillery which use these two trajectories, and for what reasons one trajectory is often preferred to another.

QUESTIONS AT THIS ADVANCED LEVEL

1. Upon what 2 things does range depend? (Angle, velocity)
2. Is it always possible to have a choice of two different trajectories when firing at a distant object?
   (Yes, except at 45 degrees.)
3. Give two reasons why air resistance can be neglected in making calculations for this projectile.
   (Short time, low velocity.)

4. If the spring is stretched twice as much, but still obeys Hooke's law, how much more energy has it? Illustrate by diagram. (4 times)
5. If the spring in Q. 4 is stretched twice as much, will it shoot twice as far? If not, what will it do? (Yes, theoretically.)
6. A 66 gram spring fired vertically reaches a height of 20 feet. What will be its maximum range in feet when fired at 45 degrees? (40 feet.)
7. A 66 gram spring possessed 6.47 joules of energy. How high could it shoot vertically, assuming no friction? (10 meters)
8. The same spring possessed 4.77 foot lb. of energy. Using the English units, find the vertical height in feet to which it could shoot. (32.8 ft.)
9. If the work done in problem 8 is equated to $WV^2/2g$ the velocity can be calculated in feet per second. What is it? (45.8 f.p.s.)
10. Calculate the velocity attained when the spring fell from the height reached in Q. 8 by the formula $v^2=2gs$, and compare with answer to Q. 9. (same)

Work at "Research" Level

An important point not usually brought out in the study of physics can be shown if the student will plot a "Hooke's Law" or stress-strain curve for the spring used. This should be made with the spring hanging freely, and the graph plotted as shown in Fig. 4. The points on the curve should be fairly close together, and connected by a smooth curve. Since a square under this curve will have its height measured in cm and its width measure in grams it is obvious that the square represents gram-centimeters, or work. Hence we might conclude that the area under the curve represents work, which is the truth, but it is not all of the truth. Let us use the data given on the graph, and plot the curve, then attempt to find the area under it, let us say for a stretch of 40 cm. The most obvious way of doing this is by direct counting of squares. The student should first take a pencil and follow along the graph, and outline the squares which will be considered under the curve. An attempt is made to leave as much area outside the graph as there is inside, thus making the area correct. The sum of the squares under the outline are then counted, and it may be found that there are 1010 squares

under the curve. This procedure is tedious, and one wonders if mathematics cannot help us out a bit in this counting. If the pupil is mathematically inclined, and especially if he intends to go into engineering work, the teacher may disclose to him that here is one of the most common problems of the engineer; and that one of the most powerful tools of human thought, the calculus, may help him solve the problem with some ease. We shall assume that the teacher is familiar with elementary calculus, but for clarity shall state a suggested plan of attack.

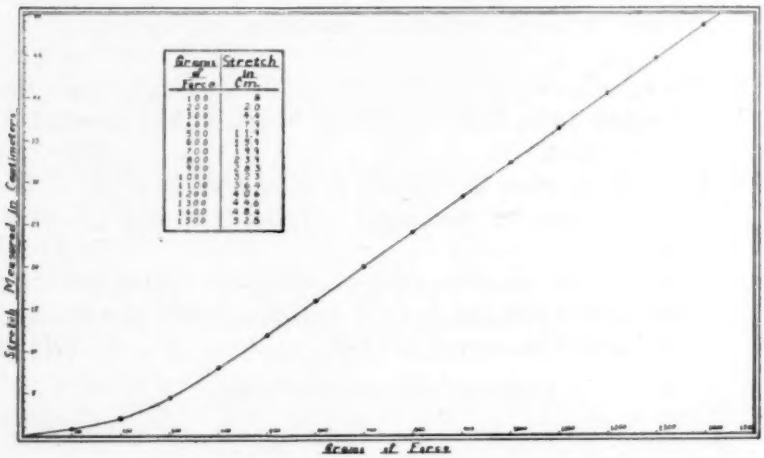

FIG. 4. The variation of strain with stress.

The first step in obtaining the area is to obtain the equation of the curve. A practical method is to ignore the curved bottom portion of the curve, and take the equation of the straight-line portion only. We use the type equation

$$y = mx + b$$

where m is the slope, or tangent of the line, and b is the intercept on the y axis. Any convenient right triangle is then drawn, using the straight part of the graph as the hypotenuse, and the number of squares in the altitude and base are counted. The slope of the graph is the altitude divided by the base; in the graph shown in the figure, the slope of the line was 8/10 or .8. Next choose any convenient point on the line whose co-ordinates are known, and substitute these values of x and y, as well as the value of m obtained above in the equation

$$y = mx + b.$$

In this way the equation of the line will be found to be approximately

$$y = .8x - 8$$

and most curtain springs will have an equation similar to, but not necessarily identical with this.

It is next necessary to integrate this equation. This can be taught as a cut-and-try method, in which we try to find an equation which when differentiated will give $y = .8x - 8$. Differentiation is very simple for these equations, and the student readily catches on how to do it after he is shown a few examples by the teacher.

First multiplying through by dx we have

$$ydx = .8xdx - 8dx$$

and without much trouble we find that the equation

$$A = 2/5x^2 - 8x + C$$

when differentiated will give the equation of the graph. C is a constant to be determined experimentally, and which takes into account the area under the curved "toe" of the graph. The value of this constant "C" is found by taking some value of x for which the area has been accurately counted, and substituting this area for A in the above equation. The proper and corresponding values of x^2, A and x are also substituted in the equation, which permits the unknown C to be determined. For the particular spring used in the experiment described, the value of C was found to be 57. This enables us to calculate the area under the curve which would be $2/5(60)^2 - 480 + 57$ or 1017 squares. Since a careful count had given us the value 1010 squares, it is seen that the probable error is small. Since our particular graph was drawn so that 1 square represented 20 gram-centimeters of work, it follows that the total area under the curve would be 20,340 gram-centimeters of work. Now if this amount of work is done in lifting a weight, or a projectile, which weighs 66 grams, it will obviously lift it 20,340 divided by 66 or 308 cm. If we check this experimentally to see how high a 40 cm extension will shoot the spring, we find that the spring will be consistently shot 375 cm high, which is nearly 20% higher than the graph shows is possible!

Hence our assumption that the work done on the spring is the area under the curve as drawn is incorrect. Let us re-draw the graph, plotting one point only, that for the 40 cm extension, for an applied weight of 1200 grams. This curve is a straight line beginning at the origin, and the area under the curve is simply

$$\frac{(40)(1200)}{2} \quad \text{or} \quad 24{,}000 \text{ gm-cm.}$$

This amount of work divided by 66 grams gives 365 cm for the height of projection. Since the observed height is 375 cm there is a 3% error which is within the limits of error of the apparatus.

This brings out very forcefully the fact that kinetic energy is $\frac{1}{2}mv^2$. When we take the area under the first curve, we are assuming that the kinetic energy is some fraction less than $\frac{1}{2}mv^2$. Then since the diagonal of a rectangle divided it in half, we assume that kinetic energy is $\frac{1}{2}mv^2$. Experiment shows that this second supposition is much nearer the truth; in fact it fits the facts within the limits of experimental error. The author is not aware that this fact is brought out as clearly and forcefully in any other physics experiment.

A Graphical Computer

Modern gunners have many aids to help them in the solution of the equations which govern the flight of projectiles. Something similar may be constructed for use with this gun. Figure 5 shows an easily made graph which solves all necessary equations relating to the trajectory of this gun. The graph is made on log-log paper similar to Dietzgen #340–L22. This is 2 cycle paper, and costs about a cent and a half a sheet. The graph as shown really consists of two graphs on 1 sheet, the base representing the stretch of the spring being repeated twice. The first half is used to get the range; the second part is used to find the velocity in feet per second, and also the maximum height in feet for an angle of 45 degrees.

To make the left half of the graph, which gives the range in feet, set the gun at 45 degrees with some care. Find the range for several spring extensions by actual measurement, using preferably a tape line, and the best estimated value for several trials at each setting. Plot these points on the log-log paper. If your release technique is correct, the points will all lie on a straight line. Draw in the line, and the range for any spring

extension within the limits of elasticity may be read off directly. Lines for 15 degrees, 30 degrees, etc., may be obtained in the same manner. They are all straight, and parallel to the 45 degree line. One end of these lines are shown at the top of the graph, and may be used with parallel rulers if desired.

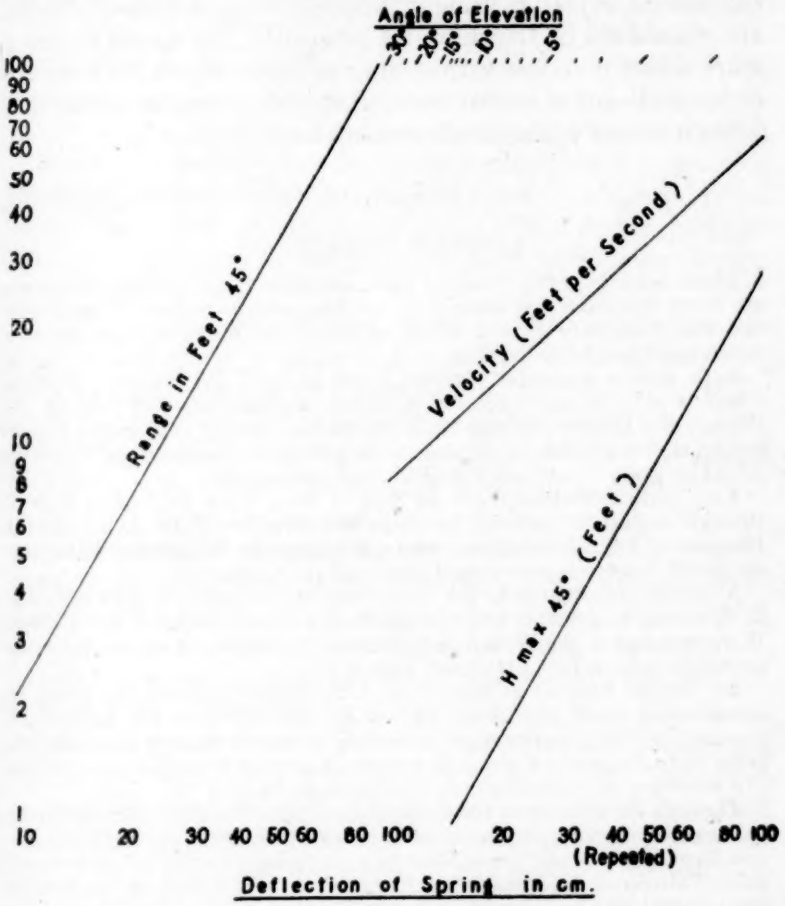

FIG. 5. Graphic solutions.

Using the range data for the 45 degree trial at various extensions, compute the velocities and plot them on the right-hand half of the graph paper. These points will also lie on a straight line. The maximum height may be computed from the formula

$$H_{max} = \frac{V^2 \sin^2 a}{2g}.$$

On the graph shown it has been computed for 45 degrees and plotted. As it plots as a straight line also, it is only necessary to calculate two points on the line. This graph is convenient when using the gun indoors, to keep from hitting the ceiling. The force of the spring is great enough to make nicks in plaster, so some care should be used in firing it. Needless to say, windows, clocks, etc., should not be struck by the projectile. The spring makes a mark where it strikes varnished or painted objects, so a square of beaver board or similar material should be used for protection when it is fired against walls or blackboards.

SUMMER WORKSHOPS

Three workshops for teachers from southern Negro college campuses are being sponsored this summer by the Cooperative Negro College Study and the Secondary School Study of the Association of Colleges and Secondary Schools for Negroes.

Both studies recognize regional needs at both the college and high school level in the three areas of guidance, mathematics, and English. As the result of these workshops there should be a number of resource people in the region capable of helping to improve the usefulness of southern school programs in guidance, English, and mathematics.

The English workshop will be held at New York University July 2 through August 10 and will be under the direction of Dr. Lou LaBrant Professor of English Education, who will arrange for the group to have contacts with numerous persons and courses at the University.

A special coordinator at the University of Chicago will give full-time to the group in guidance and the seminars and consultants of the College Workshop and of the Workshop on Human Development will be available to the group from July 30 through August 31.

Dr. Harold Fawcett at Ohio State University will direct the group in mathematics from July 26 to August 31, and will have the help of his associates in the Department of Education of the University. Last summer Ohio State sponsored a group of seventeen persons from southern schools in a workshop in evaluation under Dr. Louis E. Raths.

Through the interest of the General Education Board in increasing the regional resources for improved educational programs in southern colleges and secondary schools, ten scholarships are being awarded for each workshop. Thirteen colleges made nominations for the guidance group, ten for the mathematics group, and seventeen for the group in English. One or more high school teachers will also receive scholarships in each group.

Energy is wealth, and in the case of apprenticed sunlight, wealth of a particularly desirable kind, for it is freshly created and does not involve robbing the poor, taxing the rich, or despoiling the earth of materials which may be needed by our descendants as much as by ourselves. Yet this energy is free—to him who can discover how to capture and control it.

—George Russell Harrison in *Atoms in Action.*

SOME NOTES ON BEHAVIOR

Part Three*

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Behavior can be classified as either learned or unlearned. The essential distinction between learned and unlearned behavior is made on the basis of whether or not behavior is modified through experience. However, this modification of behavior through experience must be acquired rapidly enough so as not to be the result of structural modification and permanent enough so as not to be the result of a temporary physiological state.

The progressive development of the cerebral cortex in mammals, culminating in man, made possible the progressive replacement, by flexible responses, of the fixed response of an instinctive system characteristic of other animals.

The process of education was greatly facilitated when the protective association of parent and off-spring, so characteristic of higher types, was evolved. Family and community life carried the education process still further. A word of caution regarding the acceptance of the idea that parent animals teach their young by doing things before their eyes is in order at this point. In actual fact it is very doubtful whether any mammals, other than monkeys, apes, and man, have a sufficiently well developed imitative faculty for this kind of instruction. In experiments with puzzle-boxes it was often noticed that if animals saw one of their fellows press the right lever, or had the human experimenter repeat the trick a dozen times before their eyes, they learned nothing from it. Even if they were held and passively put through the trick themselves, it was rarely of any avail; to be learned, the movements must be their own. Even in our own species, modern educators can demonstrate how much better children remember what they have done or have been persuaded to do of their own initiative. In monkeys and apes and ourselves, the instinct to imitate brings about a great abbreviation of the education process. But how far this occurs in other mammalian species is still somewhat doubtful. Play, practically unknown outside the mammals, undoubtedly aids in the process of

* Part One and Part Two appeared in the March and May issues of SCHOOL SCIENCE AND MATHEMATICS.

education. There are many children's games which anitcipate the business of later life:

> "Behold the child among his new-born bliss,
> A six years' darling of a pigmy size
> See, at his feet, some little plan or chart,
> Some fragment from his dream of human life
> Shaped by himself with newly-learned art."

The greatest acceleration, however, of the educational process came with the invention of language; for this not only made it possible for actual experiences of one generation to be passed on to the next, but, in addition, contemporaries likewise profit by each other's experience. "I advise you not to plant your corn so early this year," says Farmer Brown to Farmer Smith. "The weather bureau notified me that we're in for a late spring."

Behavior of apes and monkeys. The bodily build and facial expressions of apes and monkeys are so like our own that we often pause to wonder just how like these creatures are to ourselves. We see a monkey fondling her baby, and it seems to us that she must be experiencing emotions similar to those of a human mother. Again, we see a sad-faced orang-outang crouched disconsolately in the corner of his cage; his forlorn expression suggests that he is thinking of his former freedom in the Bornean jungle much as a human prisoner would recall his lost freedom. But are they really experiencing thoughts akin to human ones? That has been the fascinating question which numerous experimenters have sought to solve. Noteworthy among these attempt are those of Kohler, conducted during the years 1913–1917, on one of the Canary Islands where he established a colony of chimpanzees under conditions similar to those of their natural habitat. The chimpanzees succeeded in accomplishing the following feats. They foresaw that they could use sticks to beat down bananas hanging from the roof, or to reach them lying on the ground outside the cage. They employed bigger sticks as vaulting poles to leap at suspended food. To catch ants, which are tempting morsels to an ape, they would poke a straw through the bars of their cage, and out among the ants. The ants, once having crawled upon the straw, were drawn back into the cage and licked off the straw. Most interesting of all, they could combine implements. In one experiment, Kohler arranged the following set-up: Sultan, one of the most intelligent of his chimpanzees, was put into a cage along with two sticks, and several pieces of fruit were placed outside of the bars too far away to be reached by either stick alone, but within easy reach of the

joined stick. Judged in the light of this rather simple situation, the animal's behavior seems incredibly stupid to human eyes. First he tried to reach the fruit with one stick and then with the other. This effort failing, he next pushed one stick out as far as possible, and then with the second stick pushed the first one on until it finally touched the fruit. This actual contact, Kohler notes, seemed to give the animal great satisfaction, but it didn't give him the fruit! At last, as the animal seemed no closer to a solution than at the start, the experimenter gave him a hint by sticking one finger in the opening of the larger stick directly before his eyes. But the cue failed to help, and after an hour or so of futile effort, the ape apparently lost interest and gave up the task as hopeless. He continued to play with the two sticks, however, and after some manipulation, holding the one stick in the left hand and the other in the right he accidentally got them together. With great eagerness he thrust the joined sticks through the bars and drew in the fruit.

Apes have, then, it is clear, a considerable power of solving simple mechanical problems; and they solve them, not by blind *trial and error*, but with the aid of the faculty which we call *insight*, that is, seeing the complete picture, before carrying out the acts necessary to solve the problem. But their limitations were quite as striking as their achievements. Their actions indicated that they had only the slightest insight into mechanics. They could never see that a ladder was not safe when it failed to make an angle with the ground, that their piles of boxes were unstable; and when given a choice of pulling two strings, one of which was attached to a banana, while the other merely lay close to it, they invariably pulled the string which ran straight toward the fruit, irrespective of whether it was fastened to it or not. Quite striking was the observation that usually the stick and the food both had to be visible for the apes to think out the connection between them; in common parlance, "out of sight, out of mind."

In summary we may say that the intelligence of apes while considerably more advanced than that of other animals, falls far short of the human level. Their limited association centers do not enable them to grasp many elements in one act of thought. Apes are so near the critical point, at which language and abstract thought begin, that we wonder whether we could help them to cross this threshold by continued selective breeding of the ape "geniuses!"

Human behavior. Man has acquired through the process of

evolution a nervous structure which has contributed much to making possible his complex behavior. This structure has a certain hereditary organization and at the same time extensive associational tissue possessing many potentialities. The exact form of internal organization of these associational tissues is not wholly laid down at birth, but is in part shaped by each individual separately during the course of the growth period by the process of education to which he is subjected, that is, by his experience.

Although the learned type of behavior is most prominent in man, he also exhibits, to varying degrees, behavior of the unlearned type. The high intellectual and moral culture characteristic of man is built upon the foundation of innate capacities through education. In man, unlearned and learned behavior begin to overlap early in life, and it is not always easy to distinguish one from the other. Of the unlearned type in man, sneezing, coughing, winking are common examples of the reflex order. Our reactions to light, temperature, and gravity are daily examples of tactic behavior. There is, however, much contradiction on the identification and classification of human instincts. Those receiving most attention are the maternal, sex, and self-preservation instincts. These instincts and others operate together with learned types of behavior.

Emotional behavior is an aspect of organismic behavior which usually receives very little emphasis. "An emotion is a hereditary pattern reaction involving profound changes of the bodily mechanism as a whole, but particularly of the visceral glandular systems" (Watson). The emotional development of the individual is deterimned by the interaction of this hereditary reaction pattern and the environment. The proper training and guidance of the child has been shown to be of very great importance in normal emotional development. Although the child is born with certain innate emotional responses (according to Watson they are fear, rage, and lust), it must be understood that through the process of conditioning he may learn to "be afraid," to be apprehensive, to worry and to fret. Many of the childish and adult fears are "home-grown." Only the burned child fears the flame. Children are not born with that fear. The nature of childhood and adolescent training, guidance, and education will largely determine the degree of "emotional health" or balance to be attained.

Man is credited with having the highest degree of intelli-

gence. There is, however, an important distinction between learned behavior and intelligence. Intelligence is the ability to adjust to new situations by utilizing what has been learned through past experience. The ability to learn is the necessary precursor of intelligence, but those who learn most rapidly are not necessarily the most intelligent.

Many animals have the ability to profit by past experience, by avoiding actions which bring pain and selecting those which bring satisfaction and pleasure. Dogs and horses are able to learn tricks because they are able to utilize what has been learned through past experience. For the same reason many birds learn to establish a rather stable social order within the flock. A stable social order brings harmony between the members of the flock and, therefore increases their efficiency. Harmony within the flock has positive survival value.

What, then, is the difference between the behavior of man and that of other animals? We have seen that man's unlearned behavior is essentially similar to the corresponding responses—reflex, tactic and instinctive—of lower animals. It is only within the realm of learned behavior that man seems to have achieved a higher degree of development. What, however, is the nature of this difference? Is it merely quantitative or also qualitative? What is the physical basis of this difference? Unfortunately, at the present state of our knowledge, we cannot answer these questions even with the slightest degree of certainty. The field is almost entirely unexplored, and the difficulties to be encountered in the experimental approach to these problems are formidable. However, a bit of speculation on the subject may not be entirely fruitless, as it may suggest possible ways of tackling the problems in question.

G. H. Parker states: "From separate organic compounds to organized living protoplasm we pass from one plane of organization to another and consequently from one set of properties to another. The essential properties of living protoplasm are at present no more to be understood from its constituent compounds than are the properties of water from those of hydrogen and oxygen. The properties of living protoplasm are too manifold for description. They are those properties whereby living protoplasm acts otherwise than its chemical constituents do."

L. J. Henderson states: "There is that which organizes matter in time and space."

H. V. Neal states: "If we are to understand how new proper-

ties and capacities arise in nature, we must add to the *categories* of matter and energy a third category of *organization*. In a strict sense this organizing factor is not 'mechanistic.' Certainly, organization has up to the present not been recognized as a mechanistic factor by physicists and chemists. But the evidence of such a factor in life is indisputable. Without it, the evolutionary process is incomprehensible."

Could it therefore be that with the emergence of man there has also emerged a new organization of the preexisting constituents of protoplasm, or a new arrangement of the atoms of the protein molecules characteristic of human protoplasm? Such a reorganization of protoplasm interacting with quantities previously existing in other animals, might conceivably result in the development of a higher plane of intelligence involving not only a more complex pattern of nerve paths, but also the specialization of association centers in the cerebral cortex. This plane of intelligence, which we now recognize as human, exhibits the capacities of abstraction, ideation and generalization for the existence of which in lower animals we have no evidence whatsoever. It is through the media of abstraction, ideation and generalization that man has evolved the following faculties which constitute expressions of specifically human behavior:

Linguistic faculty. This is the ability to use the *spoken word.* Although other animals can and do communicate with each other by means of vociferation and although the elements of articulate speech have been identified in our simian relatives, all evidence on the subject accumulated thus far indicates that this mode of intercommunication among animals lower than man is extremely limited, being confined mainly to mating calls, warnings of danger, and expression of contentedness or distress. In man, however, this faculty, combined with the capacities for abstraction, ideation and generalization, is virtually unlimited in scope, and has been instrumental to a great extent in shaping human civilization.

Literary faculty. This faculty manifests itself in the ability to use the *written word.* It involves a more complex sensory and neuromotor mechanism than the linguistic faculty and has therefore arisen later in the mental evolution of mankind. This faculty has had the greatest influence upon the cultural advancement of man.

Quantitative faculty. This faculty enables man to reason in terms of numbers and measurements. To appreciate the significance of this faculty in terms of human behavior, one need

only imagine the state of confusion the economic world would be thrown into, should the use of the zero disappear.

Historical faculty. This faculty enables man to record events and thus to accumulate the experiences of thousands of men over hundreds of years. From this record, through the capacity for generalization, man gleans principles and employs them as guides in planning his individual and collective future. Other animals live almost exclusively in the present, with an extremely limited capacity for utilization of their individual past experiences and with no capacity whatever for utilization of experiences of other members of their clan or even immediate family. There is no evidence that future, even in the most limited sense and in the most immediate application, exists for animals below man.

The historical faculty combines the linguistic, literary and quantitative faculties.

Scientific faculty. This faculty endows man with the ability of wondering about nature. He observes natural phenomena, analyzes them and attempts to modify them experimentally in order to apply them to his welfare and comfort. Furthermore, on the basis of experience of his own and of former generations, man *anticipates* disagreeable or disastrous natural phenomena and, with the aid of the scientific faculty, devises means of protection from them. Thus, preventive medicine and flood-control have been developed to a considerable degree.

In lower animals, this element of ***anticipation*** of untoward events is entirely lacking, and avoidance of unfavorable influences of natural phenomena is purely tactic or instinctive. Thus, Paramecium will avoid intense light and thus escape its deleterious effects. The suspension nest of the oriole—a most ingenious, admirable product of instinct—will sway in a strong wind, but will not be blown off the branch. The tree squirrel, urged by sheer instinct, will bury acorns in the autumn to store them for the winter when food is not readily available.

Spiritual faculty. Of all human faculties, the spiritual is the most difficult to define or describe. It provides an escape from the exacting, often unpleasant realities of the struggle for existence. It presupposes the working of forces neither perceivable by the senses nor characterizable by properties of matter. It assumes further that these forces are influential in molding human life and in making it more worthy and more liveable. Religion is a notable outgrowth of this faculty.

Nothing comparable has been observed in animals other than

man, and experimental procedures to ascertain the existence of this faculty among lower animals are admittedly inconceivable.

Imaginative faculty. Closely related to the spiritual faculty is the imaginative faculty which enables man to project one situation into another or superimpose unreal situations upon real ones. It also often serves as an escape from reality and, in this sense, is allied to the spiritual faculty. It differs, however, from the latter in that it deals with concrete, tangible objects whose combinations may be unnatural. Whenever this faculty involves abstract ideas or spiritual concepts, it tends to materialize them through concrete symbols.

Esthetic faculty. This faculty enables men to create and enjoy things which are pleasing to his senses, such as harmony in color and sound. This faculty, in combination with the spiritual and imaginative faculties, has been instrumental in the development and appreciation of the fine arts.

Social faculty. It is this faculty which makes human society dynamic, flexible. Through it, man can recognize and analyze problems of the superorganism, i.e., human society, in which the behavior of the individual is a dual one, that is, resulting from both inherited emotional drives and cerebral inhibitions.

Social life of other animals, notably insects, is fixed and static and constitutes the product of blind, instinctive forces.

Philosophical faculty. This faculty gives to man what might be called *wisdom.* All other human faculties contribute to and probably culminate in this faculty. It enables man to understand some of the perplexities of life and to approach life realistically.

These human faculties at the time of the emergence of man must have been present only as potential factors. However, in time and space and under the guiding and molding hand of education, these originally undifferentiated potencies grew and developed into the complex and useful human faculties as we know them today.

The chief defenses of democracy are not material. They are mental and spiritual. At the very foundation of the structure of democracy must be a sound system of public education.

—Calvin Coolidge.

A THREE-LEVEL ASSIGNMENT FOR GENERAL SCIENCE

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Science teachers seeking a variety in their teaching may be interested in a description of the A-B-C Plan. For those who are striving toward a more individualized method, this modified three-level assignment plan may offer some suggestions.

DESCRIPTION OF THE PLAN

One desirable feature of the plan is the provision for a challenging assignment. Activities are listed for each of the three grade levels. The C level activities are included in both the A and B levels. The A assignment may include all of the B and C plus others, or it may just include the C assignment plus others. Each assignment may be placed on the blackboard or mimeographed. Differences between the levels are in difficulty, quantity, or both. The A and B level activities are optional.

The time element is an important factor. One assignment should be planned to extend from one to five days. The effectiveness of the plan is lessened by a lengthy assignment. Each unit is composed of several assignments with the A-B-C activities listed for each assignment. Time limit for the assignment must be determined by the teacher.

All of the stimulating student activities made possible by the science curriculum are included in the assignments. For example, there may be reading, answering questions, solving thought-problems, making drawings, making posters, keeping scrapbooks, giving oral and written reports, recording experiments, making collections, reporting on field trips, reporting on special projects, or participating in a dramatization or mock-radio broadcast. With some assignments students may suggest activities according to their interests.

Evolving from the basic C assignment are the class discussions, teacher talks, experiment-demonstrations, slides, movies, oral reviews, vocabulary drills, and tests. There is usually need for some oral work daily, particularly at the beginning of the class period for the purpose of clarifying problems, or making suggestions. Students busy with activities are helped individually. Compliments where deserved are valuable encouragement.

This plan calls for a maximum of student effort and responsibility. In no way, however, does this decrease the teacher's responsibility. The activities are checked and graded for each assignment, either at the close of the assignment, or at the conclusion of the unit. Motivation stems from the desire to achieve, but it is the teacher's responsibility to see that the students are led to recognize worthy purposes. Many of the activities are self-motivating when once underway, because of the students' natural interest in the subject or activity.

Some of the advantages of the A-B-C Plan are as follows: provision is made for individual differences in abilities, needs, and interests; provision is made for a wide variety of activities, and experiences; provision is made for use of a textbook plus available reference material; provision is made for student cooperation in assignment construction; and, students like the plan.

Knowledge of the weaknesses of the plan may help to overcome them. For example, the A and B assignments may usurp worthwhile activities at the expense of the C. Over-emphasis of letter grades may sponsor a striving toward undesirable objectives. Dull-normal students may become discouraged if unable to complete the C and B levels time after time.

With few exceptions all written student evaluations made by students of all levels of ability have included comments of approval. Some which have appeared many times are: "I like the plan, because you get what you earn; I like the activities of the A-B-C Plan; I like the A-B-C Plan, because it is fair to the student; The A-B-C Plan makes me feel more like working; and, With the A-B-C Plan I get more out of science."

Teaching Suggestions

All students use the assignment as a guide to self-directed activity. The assignment may begin with the raising of a problem as an outgrowth of the previous assignment. The class will usually start together on the reading activity, and strive first toward the completion of the C level activities. Those who complete one level before the others, work toward the completion of the activities in the next level. Student participation in activities characterizes the class period, but extensive use must also be made of supplementary teaching devices such as those previously mentioned.

At the conclusion of the assignment there is an oral review

followed by a test. Often the C problems may be used as a basis for this review. Finished activities are then presented. Those that are written are collected, graded, and returned as soon as possible. For some units it may be feasible to have the students retain their work on each assignment until the end of the unit.

Oral reviews covering all of the assignment problems should come at the conclusion of the unit. Activities for the last assignment are checked, graded, and returned. A unit test culminates the unit.

Preparation of the Assignment

In constructing plans for a unit in science the unit must first be divided into several assignments. For each assignment A-B-C activities are given. Textbook questions, problems, and activities may be used, or duplicated assignment sheets prepared with original material. A blackboard assignment directing the students to certain questions, thought-problems, and suggested activities in the text may be a desirable procedure. The duplicated assignment, however, offers many advantages, particularly when a wide use of reference material is possible.

In the example of an A-B-C assignment which follows, the assignment problem is one of several assignments which compose the unit on disease. Activities one, two, and three form the basic C level. The difference between the B and C requirements is one activity. The difference between the A and B levels is also one activity. In each case the activity required for the upper level not only involves more time, but is of a more difficult nature demanding superior thought.

No single example can indicate the many desirable possibilities encompassed by this assignment plan. The impetus for learning generated by a three-level assignment may certainly be profitably used, especially under the direction of a teacher who keeps foremost in mind the real purposes of education.

Example of the Assignment

Unit Problem: How can we protect ourselves from disease?

Assignment Problem: How can we prevent the spread of disease germs?

"A" Activities. Complete correctly activities one, two, three, four, and five.

"B" Activities. Complete correctly activities one, two, three, and four.

"C" Activities. Complete correctly activities one, two, and three.

Activity One

For help in solving this problem read in *Health For You* by Katherine B. Crisp, pp. 382–400.

Activity Two

Directions: Complete the following outline. After each question or problem write the answer. Fill in the blanks of the completion statements with the word or words to make the sentence correct.

I. How germs enter the body.
   A. Name three entrances through which germs get into the body.
   B. What habits or practices help germs in their travels from one person to another?

II. How germs may be destroyed outside the body
   A. How may objects be sterilized?
   B. In what ways are chemicals used to check the growth of germs, or to kill germs?
   C. Nature's best germ destroyer is _____.

III. How germs may be prevented from leaving the sick-room
   A. What precautions should be taken when a member of the family is ill with a communicable disease?
   B. When should a person be quarantined?

IV. How the body fights disease
   A. How may the body defenses be weakened?
   B. How do the white corpuscles help protect us from infection?
   C. What barriers does the body have against disease germs?
   D. In what ways do antibodies guard the body from diseases?
   E. The ability to resist disease is called _____.
   F. Everyone is born with a certain degree of _____ against some disease germs.
   G. Active immunity is developed by the body through the effects of _____ or _____ entering the system.
   H. Passive acquired immunity is obtained by the injection of an immunizing _____ or _____.

V. How smallpox can be prevented
   A. How does the death rate from smallpox now compare with the death rate in the 1700's?
   B. Describe the nature of this disease.
   C. How did Edward Jenner first prove the value of the cowpox vaccination?
   D. How is smallpox vaccine prepared?
   E. Following the vaccination, immunity against smallpox lasts for about _____ years.
   F. Why is a smallpox vaccination mark a badge of good citizenship?

VI. How we can protect ourselves from diphtheria
   A. How are diphtheria bacteria spread?
   B. Why does the doctor make a diphtheria culture?
   C. The incubation period for diphtheria is _____ days.
   D. Describe how diphtheria antitoxin is obtained and used.
   E. What does a positive reaction to the Schick test mean?
   F. How does toxoid differ from the toxin-antitoxin?
   G. A person should be immunized against diphtheria when he is about the age of _____ _____.
   H. When was diphtheria considered the most dreaded disease of childhood?
   I. How can all parents of today protect their children from this disease?

VII. How scientific prevention of disease has reduced the danger of typhoid fever.
   A. Why is typhoid fever more common today in the rural areas than in the larger cities?

B. Describe the nature of this disease.
C. List four ways in which typhoid fever may be spread.
D. Following a typhoid fever vaccination, immunity lasts for about _____ _____.
E. One of the greatest obstacles to successful control of typhoid fever is the _____ _____.
F. What precautions against typhoid fever should one take on a vacation trip?

Activity Three

Read the story of *Edward Jenner* by Grace T. Hallock and C. E. Turner in *Health Heroes* series, Met. Life Ins. Company. Write a report describing his most interesting experiences. How did his greatest discovery affect the lives of the people?

Activity Four

Read *Typhoid Fever, Cause-Transmission-Prevention*, Educational Health Circular Number 7, The Illinois Department of Public Health. Make a written report. Find out when the last typhoid fever epidemic covered Rockford. Why is this not likely to happen today? Make a list of all the possible ways typhoid fever germs may be spread. Study tables III and IV on page 18 of the pamphlet. What conclusions may be drawn from the data presented there?

Activity Five

Plan and participate in a mock-radio broadcast on the subject, "The Spread of Disease." Read *Helpful Hints About Public Health*, Educational Health Circular Number 1, Illinois Department of Public Health. Make twenty questions and answers which can be used in a question-answer discussion for the broadcast before the class.

D. C. HEATH AND COMPANY CELEBRATE

D. C. Heath and Company this year will celebrate sixty years of publishing. Late in 1885 the publishing firm of Ginn and Heath was dissolved and the new firm, established by Daniel Collamore Heath, started on its way with thirteen books and eleven pamphlets. These were chiefly in science and modern languages, two subjects that Mr. Heath had the vision to anticipate would play an important part in future school curriculums. In a recent interview, Mr. Dudley R. Cowles, president of D. C. Heath and Company, said, "We were fortunate that in our early years our steps were guided by men who as experienced educators believed strongly that an important part of their business was to advance the cause of American education by making as good books as it was possible for us to make. That purpose has remained a guide to the Company ever since. During the last sixty years Heath has pioneered in new fields, and recently has developed a large and strong list in the elementary field. In the high school and college fields Heath is going vigorously ahead to keep abreast of the many educational changes that a changing world demands. We have produced an increasing number of texts meeting educational requirements so closely that several of our series have been and are being used by the millions."

ALGEBRA AND ARITHMETIC

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Beginning algebra texts present + and − numbers as an entirely new topic which has no roots in the arithmetic of the previous eight years. Textbooks on arithmetic, on the other hand, offer no hint or suggestion of algebraic thinking. The two subjects are locked into watertight compartments. In opposition to this sharp cleavage in subject matter, we shall attempt to show *in detail* that arithmetic is capable of providing a *complete root system* for the development of algebra.

DISTRIBUTIVE LAW

As an illustration of the way in which algebraic thinking can be initiated in arithmetic, let us assume that a pupil has been earning $7 a week (pre-war) for three weeks and $9 a week for another three weeks, and that he wishes to find the total amount earned. The arithmetic procedure would be as follows,

$$3\times 7=21,$$
$$3\times 9=27,$$
$$21+27=48.$$

This gives the teacher an opportunity to point out that,

$$3\times 7+3\times 9=3(7+9). \tag{1}$$

Thus the amount earned can be computed alternatively as,

$$3\times 16=48.$$

The fact that the right and left hand sides of equation 1 lead to the same numerical result should not be the sole source of conviction of the correctness of that equation. On the contrary, pupils should understand that 3 (7+9) is,

$$\begin{array}{r} 7+9 \\ 7+9 \\ 7+9 \\ \hline 3(7)+3(9). \end{array}$$

Viewed in this way, equation 1 is obvious.

The distributive law expressed by equation 1 is *implicit* in

every multiplication problem, but this fact is obscured by the details of place value and carrying. Thus the multiplication of 43 by 5 amounts to,

$$5(40+3)=5(40)+5(3). \tag{2}$$

Multiplication procedure takes account of this fact, *as of course it must*. Unfortunately, the carrying of the 10 and the observance of place value are attention demanding details under which the simple pattern of equation 2 is completely hidden. The result is that pupils are unaware of the principle unless it is pointed out by the teacher, not once, but repeatedly.

On the other hand, "mental arithmetic" procedure emphasizes the distributive law. In the present instance it would follow equation 2. Thus,

$$5\times 40=200,$$
$$5\times\ 3=\ 15,$$
$$200+15=215.$$

The multiplication of denominate numbers offers another opportunity to emphasize the distributive principle. For example, to double a length such as,

3 yds. 1 ft. 2 in.,

it is necessary to double the number of *each* denomination. It will be recalled that arithmetic numbers are simply denominate numbers in which the denominations are units, tens, hundreds, etc.

Operational Identities

In addition to the distributive law the following operational equalities should be made familiar to every pupil.

1. $a+(b+c)=a+b+c,$
2. $a-(b+c)=a-b-c,$
3. $a+\ b-b\ =a,$
4. $a+(b-c)=a+b-c,$
5. $a-(b-c)=a-b+c.$

Equations 1 to 5 are algebraic identities, but as such they are also arithmetic principles. Like the distributive law they are fundamental to arithmetic and enter into every computation.

Despite this fact pupils (and teachers) are unaware of their existence—like Monsieur Jourdain in Molière's *Le Bourgeois Gentilhomme* who had spoken prose all his life without realizing it. The task of the teacher who appreciates their significance for algebra and arithmetic is to make the pupil *conscious* of them.

Equation 1, e.g. states that the addition of the sum of two numbers may be performed on the "installment plan." That is to say we may add first the one number and then the other. This is exactly what occurs in the problem of adding e.g. 47 to 125. The 7 is added and then the 40, but this very simple fact is obscured by the concentration upon place value and carrying. On the other hand, the principle stands out clearly in the "mental arithmetic" procedure,

$$125+40=165,$$
$$165+\ 7=172.$$

Equation 2 states that subtraction, like addition, may also be performed upon the "installment" plan. Thus to subtract 36 from 83, mentally, the "inner speech" is,

$$83,\quad 53,\quad 47.$$

Equation 3 states the obvious fact that adding a number and then subtracting it leaves the minuend unchanged.

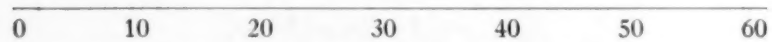
Equations 4 and 5 are less obvious but more intriguing. They supply mental arithmetic procedures such as,

$$54+29=54+(30-1)=54+30-1=84-1=83,$$
$$54-29=54-(30-1)=54-30+1=24+1=25.$$

Thus adding 29 is equivalent to adding 30 and subtracting 1. Similarly, subtracting 29 is equivalent to subtracting 30 and then "restoring" 1.

Arithmetic Scale

Equations 1 to 5 become strikingly intuitive when interpreted on an arithmetic scale such as the one below. For example, the fact that



adding 29 is equivalent to adding 30 and subtracting 1 is visualized as proceeding 30 steps to the right, which is one too many, and then compensating by going back one step to the left.

Similarly, the subtraction of 29 is pictured as "falling back" 30 steps to the left and then canceling the one step too many by a step to the right. In like manner the addition of 43 as an addition of 40 followed by one of 3, and the subtraction of 37 as a subtraction of 30 followed by a subtraction of 7, are effectively pictured as successive right and left displacements respectively.

These statements recall the combining of + and − numbers and it is, therefore, easy to understand that the one-way arithmetic scale is the forerunner of the two-way algebraic scale.[1] The teaching of these two scales is therefore another instance of the way in which arithmetic can provide roots for the development of algebra.

Literal Numbers

Although literal numbers lead quite naturally to the invention of + and − numbers, the two concepts are *logically* independent of each other. In beginning algebra, unfortunately, these topics are introduced simultaneously. Not only does this produce a *twofold* difficulty in itself but, in addition, further confusion is generated by the subconscious notion that the two concepts are mutually interdependent. Grade School arithmetic offers an opportunity to separate these difficulties by offering practice in the use of literal numbers *independently* of the concept of + and − numbers.

Consider e.g. the following problem. Divide a pole 20 ft. long into two parts so that one part shall be three times as long as the other.

1. *Arithmetic Solution*

The shorter part is a certain length. The longer part is three times this length. The entire pole is then four times as long as the shorter part. The shorter part is one-fourth of 20 ft. or 5 ft. The longer part is three times 5 ft. or 15 ft.

2. *Algebraic Solution*

Let x = no. of ft. in the shorter part,

then $3x$ = no. of ft. in the longer part,

and $x+3x=20$,

$4x=20$.

$x=5$, Check: $3\times5=15$,

$3x=15$. $15+5=20$.

[1] See author's paper, "The Algebraic Number Scale," this journal, Jan. 1944, pp. 40–44.

The transition from the arithmetic to the algebraic solution will present very little difficulty. Pupils will be quick to appreciate the fact that the use of literal numbers, such as x, makes for conciseness and ease in pursuing the train of thought. If both methods are employed in a number of problems, the one will clarify the other and pupils will have an opportunity to observe the effectiveness of literal numbers.

Additional experience in the use of literal numbers which would stimulate algebraic thinking is to be had in "think of a number" games. These games are interesting from the 6th grade on and provide problems which present a wide range of difficulty.[2]

Negative Numbers

The most striking difference between arithmetic and algebra lies in the fact that algebra employs negative (and positive) numbers but arithmetic does not (at least not consciously). Textbooks in algebra frequently emphasize this fact as an element of novelty. As we have remarked in the beginning, they stress the idea that positive and negative numbers are something entirely new which the pupil has never seen before.

The theory of the novelty approach is that algebra gives the pupil who is bored with arithmetic a respite from that subject and an opportunity to work with a refreshingly different type of material. On the contrary, as we shall indicate shortly, the + and − numbers of algebra are merely a sophisticated version of the arithmetic add and subtract. From this it follows that every problem in addition and subtraction presents an opportunity to orient the pupils' thinking in the direction of + and − numbers.

More specifically, since "negative numbers" grow out of a desire to make subtraction the exact counterpart of addition, it is evident that anything which tends to place the former on an equality with the latter aids in developing this concept. For example, the subtraction facts should be learned simultaneously with those of addition and should be accorded the same status. Thus the pupil should know that,

$$9+3=12,$$

and

$$12-3=\ 9.$$

[2] See author's paper, "Think of a Number," this journal, Oct. 1944, pp. 624–628.

In terms of the arithmetic scale, the pupil should not only be able to count 3 steps forward from 9 to 12, but he should be equally able to count 3 steps backward from 12 to 9.

A very considerable obstacle to making subtraction the counterpart of addition lies in the fact that the entire structure of arithmetic is *pointed* in the *direction* of *addition*. Thus when we write 2.98 we are saying in effect, that to obtain the number in question, start with 2, *add* .9 and finally *add* .08. On the other hand we can evidently reach the same point (on the arithmetic scale) by starting at 3 and proceeding .02 of a unit to the left. Thus

$$2.98 = 3 - .02.$$

To multiply 2.98 by 4, e.g., the customary procedure is to multiply successively .08, .9, and 2 by 4, whereas 4 (3 − .02) would be much simpler. Since integer multiplication signifies repeated addition, this in turn would mean,

$$\begin{array}{r} 3 - .02 \\ 3 - .02 \\ 3 - .02 \\ 3 - .02 \\ \hline 12 - .08 = 11.92. \end{array}$$

Incidentally, we note that,

$$4(3 - .02) = 4(3) - 4(.02),$$

which emphasizes the distributive law in connection with subtraction. In like manner,

$$\tfrac{1}{5}(99) = \tfrac{1}{5}(100 - 1) = \tfrac{1}{5}(100) - \tfrac{1}{5}(1) = 20 - .2 = 19.8.$$

Finding Averages

Let us suppose that a teacher wishes to compute the average of the following 6 grades,

$$\begin{array}{rl} 75 = & 70 + 5, \\ 83 = & 70 + 13, \\ 82 = & 70 + 12, \\ 78 = & 70 + 8, \\ 70 = & 70 + 0, \\ 74 = & 70 + 4, \\ \hline & 6(70) + 42. \end{array}$$

As we have indicated, each grade is expressible as the least one, 70, + some number. To find the average we divide the total amount, which is 6 (70) +42 by 6. Thus,

$$\frac{6(70)+42}{6}=\frac{6(70)}{6}+\frac{42}{6}=70+7=77.$$

The procedure up to this point has been in harmony with the *additive bias* of arithmetic. If we adopt an equally extreme *subtractive* point of view, the averaging of the 6 grades takes the form,

$$\begin{aligned}
75 &= 83 - 8,\\
83 &= 83 - 0,\\
82 &= 83 - 1,\\
78 &= 83 - 5,\\
70 &= 83 - 13,\\
74 &= 83 - 9,\\
&\overline{\qquad\qquad 6(83)-36,}
\end{aligned}$$

since each grade is equal to the largest one, 83, − some number. To find the average we divide the total amount, 6 (83) − 36, by 6. Thus,

$$\frac{6(83)-36}{6}=\frac{6(83)}{6}-\frac{36}{6}=83-6=77.$$

To arrive at the *golden mean* with respect to method, we adopt a middle of the road procedure which combines the additive and subtractive points of view. The meaning of average is emphasized by selecting an *average* number (in the set or out of it) which seems likely to be, if not *the average*, at least a good approximation of it. The median is an obvious candidate for this role. In fact, it *is* the arithmetic average if the numbers form an arithmetic progression.

The numbers of the set are equal to this selected number ± some amount. Thus with 75 as an "assumed" average, we have the schedule as shown at the top of the following page.

For a check upon this computation we can employ one of the other two procedures or the more conventional method of dividing the sum of the grades, as they stand, by their number.

In each of the three procedures it is evident that we obtained

$$\begin{aligned} 75 &= 75 + 0, \\ 83 &= 75 + 8, \\ 82 &= 75 + 7, \\ 78 &= 75 + 3, \\ 70 &= 75 - 5, \\ 74 &= 75 - 1, \\ \hline & 6(75) + 12. \end{aligned}$$

$$\frac{6(75)+12}{6} = \frac{6(75)}{6} + \frac{12}{6} = 75+2 = 77.$$

the *true* average by adding to the *assumed* average one-sixth of the sum of the "discrepancies" between the latter and the individual numbers. In the first procedure they are all +, in the second all −, and in the third + and −. The compromise procedure evidently gains its effectiveness by the cancellation of + and − "discrepancies." If the canceling is *complete* it means that we have estimated correctly and that the average which we have assumed is the *true* average. It is evident, too, that we can use this fact as a check on the computed average. The problem of averaging introduces the pupil therefore to a very effective use of + and − numbers in an *arithmetic* setting in which their add and subtract meaning is perfectly apparent.

Checking Account

As a concluding instance of the way in which arithmetic thinking can be directed into algebraic channels, consider a checking account which is started with a deposit of 100 (we shall omit the dollar sign), and let us suppose that the following deposits and disbursements are made, dep. 25, dis. 15, dep. 20, dis. 5.

For the arithmetic pupil this would mean the following series of additions and subtractions,

$$(4) \qquad \begin{aligned} 100+25 &= 125, & 125-15 &= 110, \\ 110+20 &= 130, & 130-\ 5 &= 125, \end{aligned}$$

which may be "telescoped" into,

$$(5) \qquad 100+25-15+20-5 = 125.$$

Equation 5 signifies that we are to add 25 to 100, from this result subtract 15, etc.

Employing the term minuend in an *extended* sense as a number to or from which a second number is added or subtracted respectively, we may say that there are four successive minuends in equation 4. The fact that only the first of these appears *explicitly* in equation 5 tends to subordinate the *minuend role.* The result is that the + and − signs in that equation are associated with the addends and subtrahends which they precede. Thus the − sign preceding 15 is "appropriated" by that number due to the fact that the minuend with which it is shared is present *implicitly* only, as 100+25. From these considerations it is evident that equation 5 is a big step in the direction of + and − numbers.

It is clear, however, that instead of following the steps indicated we may e.g. combine all the deposits subsequent to 100 into a single deposit item. Similarly for disbursements. If this is done the problem takes the form,

$$100+45-20=125.$$

If 45 had been the initial deposit and 100 the sum of the subsequent deposits we should have,

$$45+100-20=125.$$

Since 45 and 100 have the same status as deposit (additive) items, it seems appropriate to recognize this fact by prefixing a + sign to each. Hence,

$$+45+100-20=+100+45-20=+125.$$

Going back to equation 5 it is evident that in place of adding 25 and subtracting 15 we may, if we wish, subtract 15 from 25 and add the net result to 100. That is to say, we may carry out a series of additions and subtractions in any order *providing that an adequate minuend is available for every subtraction.* In other words, subject to the limitation noted, we may reorder the terms of equation 5 in any way that we please, providing, of course, that no item is changed with respect to numerical *value* or *sign.* As is well known, the second requirement is much more difficult to observe than the first. We are not likely to alter the "absolute" value, but like "winding up the cat and putting out the clock," we can, and do, get the signs "turned around."

As in language teaching where the article is learned *with* the noun (der Mann, la femme), we are led to adopt the psycho-

logical device which consists in thinking of each sign as firmly attached to the number which it precedes. Prefixing a + sign to an initial deposit item evidently aids in making this transition.

In recognition of the changed point of view we abandon the add and subtract terminology and speak of + numbers and − numbers. Collectively, they may be described as + and −, or signed, numbers. In this way the + and − signs are shifted from a *verbal* to an *adjectival* role. As adjectives, they "modify" the arithmetic numbers to which they are prefixed.

The conventional terms, positive and negative, do not in the least suggest the add and subtract meaning which is at the back of + and − numbers. They are therefore a distinct handicap to clear thinking and should be eliminated from the vocabulary of algebra. If there is need for a trisyllabic terminology to take the place of positive and negative, we could employ the verbal adjectives additive and subtractive, which are transparent in meaning.

The interchangeability of additions and subtractions is expressed, therefore, as follows: + and − numbers can be combined in any order, ***provided that the + numbers are not outweighed by the − numbers*** at any stage in the procedure. The combining of signed numbers exhibits, therefore, great *flexibility* together with a *severe restriction*. The following considerations indicate how algebra is made possible by removing this handicap.

We shall begin by considering the problem proposed by the equation,

(6) $$3-5+4=?$$

or as we prefer to write it,

(6)′ $$+3-5+4=?$$

In its present form with the implication that a −5 (subtraction of 5) is to be combined with a +3 (addition of 3), the problem is impossible under the restriction stated. However with (+)7 resulting from +4 and +3 as an adequate minuend, we may separate −5 into −3 and −2. The +3 followed by −3 gives zero. This leaves −2 as a deferred or left-over subtraction which we can proceed to combine with +4 to produce a final (+)2.

Consider now the problem presented by

$$+15-35=?$$

Ignoring for the moment the question, how is it possible to subtract 35 from 15, we may in a purely formal way, *despite* the lack of an *adequate minuend*, proceed to separate -35 into -15, -20, cancel -15 against $+15$ and have a -20 remaining. Since there is no additive item or minuend to take care of -20 we are left, this time, with a not merely "deferred" but "permanent" subtraction. It is evident that this problem, which begins and ends with an impossible subtraction, represents a definite break with arithmetic thinking.

Double Entry Bookkeeping

In modern bookkeeping each ledger account is provided with a debit and credit side. In customer accounts, e.g., purchases are debited and payments are credited. The present problem is readily interpreted as a payment credit of 15 followed by a purchase debit of 35. There is no difficulty in picturing customer accounts in which the debits exceed the credits. In fact such accounts normally present this appearance. At intervals only does the credit total overtake the purchase debits. The separation of -35 into -15 and -20 amounts under the bookkeeping point of view to considering the one debit item to be made up of two partial debits. The -35 could, in fact, have come about from purchases of 15 and 20 respectively. The cancellation of -15 and $+15$ with -20 remaining corresponds to the fact that the payment credit of 15 takes care of the debit of 15 and leaves a remaining one of 20. We see, therefore, that the bookkeeping point of view enables us to think our way step by step with perfect clearness through a situation which from beginning to end is impossible under arithmetic conceptions.

If the signs in equation 7 are reversed, we have

$$+35-15=? \tag{8}$$

In this case we *could* lapse into the arithmetic,

$$35-15=(+)20.$$

Under the bookkeeping point of view we have a credit item of 35 and a debit of 15. There is no difficulty in separating $+35$ into $+15$ and $+20$, i.e., a payment of 35 may be replaced by partial payments of 20 and 15. The cancellation of $+15$ and -15 with $+20$ remaining is easily explainable on the ground that a payment of 15 cancels a debit of 15, leaving a net credit of $(+)20$.

Two cases remain to be considered

(9) $$-15-35=?$$

(10) $$+15+35=?$$

Equation 9 is interpreted as a debit of 15 followed by another of 35, making a total debit of 50, (-50). Equation 10 may be interpreted arithmetically as

$$15+35=(+)50.$$

In bookkeeping terms we have a credit of 15 followed by another one of 35, making a total credit of 50, $(+50)$.

Consider again a problem of the type with which we began.

(11) $$100-20+30-50=?$$

Under arithmetic conceptions we should subtract 20, add 30, and subtract 50, obtaining 60 as the result. If we wish to consider $30-50$ independently of the other terms, we can continue under arithmetic guidance if we separate -50 into -30 -20 on the strength of the preceding 80, $(100-20)$. On the other hand, if, without regard to its presence we still went ahead and separated -50 into -30 -20, we should be adopting the bookkeeping, debit-credit point of view and obtain as a result a debit of 20, (-20). Finally, having carried through the $30-50$ detail, we might recall the presence of the other items, i.e. $100-20$, to these adjoin the -20 obtained, and reach a final result of 60.

We see, therefore, that we can bring the bookkeeping point of view into a problem which is feasible arithmetically and obtain the arithmetic result. In these cases the bookkeeping "philosophy" gives merely greater flexibility in carrying out the operations. If, on the other hand, the problem is impossible arithmetically, the bookkeeping point of view is still available and gives an unambiguous "bookkeeping answer."

Conclusion

We have cited a number of instances of the way in which algebraic thinking can be initiated in arithmetic. In the writer's judgment this material is less difficult and considerably less boring than the commercial arithmetic (stocks, bonds, etc.) which occupies so much of the time in 7th and 8th grade arithmetic.

Moreover, it is a truism that subject matter tends to gravi-

tate to lower and lower levels of instruction. This is not because successive generations are more intelligent. It means simply that in the course of time the material is simplified and stripped of irrelevant difficulties. Euclid, for example, was considered a college subject in the early days of Harvard and Yale, but today a streamlined version of it is the standard offering of the second year of high school.

The suggestions which we have made are in conformity with this tendency. It is reasonable therefore to anticipate that in the not very distant future algebra will have its informal beginnings in the 7th and 8th grades. In like manner there is no very good reason why the elements of double entry bookkeeping could not also be taught in these grades. It is the logical culmination of the storekeeping which begins in the kindergarten. Pupils would find the "trial balance" challenging and interesting, and a perfect example of a self-checking problem.

THE PLACE OF SCIENCE IN THE EDUCATION OF THE CONSUMER

A committee of the National Science Teachers Association, affiliated with the National Education Association, is preparing a report which will deal with "The Place of Science in the Education of the Consumer." This report is one part of a larger study which is in preparation by the Consumer Education Study of the National Association of Secondary School Principals. Additional reports are in preparation by national groups in the subject matter fields of Business Education, Home Economics, Mathematics, and Social Studies.

The National Science Teachers Association report on "The Place of Science in the Education of the Consumer" will in general cover the following:

a. What is consumer education?
b. How does the definition of consumer education, accepted as basic to the report, relate to teaching in the field of science?
c. Acceptable methods and materials now in use by science teachers in the education of consumers (with illustrations).
d. Proposals for continuing and improving the use of science in the education of the consumer.

Teachers interested in criticizing a first draft of this NSTA report and in offering suggestions for materials to be included in the report may correspond with Committee Chairman, Nathan A. Neal, Cleveland Board of Education, Cleveland 14, Ohio.

Ideas are, in truth, forces. Infinite, too, is the power of personality. A union of the two always makes history.

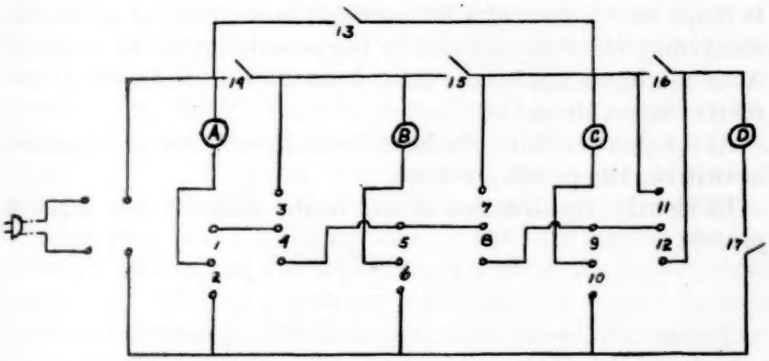
—William James.

CIRCUIT PRACTICE BOARD

E. B. CHRISMAN
John R. Rogers High School, Spokane, Washington

An easily assembled piece of apparatus which will find a place in any high school physics or elementary electricity class, is the circuit practice board. Used to test the correctness of circuits worked out by the students in class, it will provide maximum student participation while yet serving as a demonstration piece. Several years of use of the apparatus in teaching fundamentals of electricity have demonstrated its usefulness.

Essentially the board provides means of visually demonstrating a large number of series and parallel wiring combinations involving four sixty-watt lamps. The diagram, making use of six single-pole double-throw switches, five single-pole single-throw switches, and one double-pole single-throw switch, is self explanatory. Mounted on a board of about fourteen by thirty inches, it should be tilted at a convenient angle to increase visibility for the class. The board should be painted or varnished before the assembly is mounted. Then after the switches and lamps are in place, the wiring diagram should be painted on, in contrasting color. Actual wiring should be concealed under the board.



A suggested method of use is to place the wiring diagram on the blackboard for the students to copy. After this the apparatus is produced, and a problem or two placed before the class, such as

1. Connect lamp B alone.
2. Connect lamp D alone.

A student signifying he knows how may be called on to test the circuit he has devised. Before closing the switches he should indicate the numbers of those he intends to close. Success or failure is immediately apparent to all, especially if the student stands behind the apparatus while operating it, so everyone can see.

A few of the many possible combinations will serve as suggestions for further problems.

3. Connect lamps A and C in parallel.
4. Connect lamps B and C in series.
5. Connect lamps A, B, C, D in series.
6. Connect lamps A, B, D in parallel.
7. Connect lamps A and C in series.
8. Connect lamps A and B in series, and the combination in parallel to D.
9. Connect lamps A and B in parallel to each other and in series with C.
10. Connect lamps A and B in series with each other, and the combination in parallel to C and D in series.

Care should be taken to begin with simple combinations, as the inability of some students to trace circuits will probably be surprising.

Special caution should be emphasized in using the circuit board, as it is operated on the 110 volt line, and has exposed connections. Requiring the main switch to be opened while the numbered switches are being closed provides good experience. Perhaps the element of a little danger in the form of a possible shock may be of some value in the experience of the student. After all, home appliances should not be tinkered with, if the current is not turned off.

As for short circuits, the board is fool proof. No combination of switches can produce a short.

Incidently, construction of the board makes a fine student project.

HIGH VACUUM RESEARCH FELLOWSHIP ESTABLISHED

A graduate fellowship in high vacuum research has just been established at the Massachusetts Institute of Technology with funds donated by the National Research Corporation of Boston. An initial grant of $2,500 has been made. It is expected that the award will foster interest in new processes performed under high vacuum in the fields of chemistry, physics, metallurgy, and chemical and mechanical engineering.

A CHRONOLOGICAL SURVEY OF PUBLISHED RESEARCH STUDIES RELATING TO BIOLOGICAL MATERIALS IN NEWSPAPERS AND MAGAZINES*

W. EDGAR MARTIN
University High School, Ann Arbor, Michigan

If it can be assumed that what people read in magazines and newspapers every day is a valid guide for determining, in part, what subject-matter should be taught in a program of *general education*, then the kinds of scientific materials appearing in magazines and nespapers should furnish evidence as to some of the basic understandings which must be developed in courses in science to permit of an intelligent reading and comprehension of these materials.

A number of research investigations have been undertaken for this purpose, for each of the areas of science which are found in the curriculum of the secondary school. Some of the more significant of these studies have been made to secure data relative to the biological materials appearing in current literature.

The pioneer study in this area was that of Finley and Caldwell,[1] made in 1923, to determine the types of biology which go to the public through the press. An analysis was made of such materials in issues of newspapers which were representative of the following types: those having large circulation and wide distribution; those with more limited circulation and narrow distribution; those published in large cities and small cities. From the seventeen full months' issues of 492 different papers, a total of 13,795 pages was analyzed and 3,061 biological articles were secured. Twenty-eight hundred forty-five of these articles were found to be devoted to the four topics; Health, Animals, Plants, and Food. From their findings the investigators concluded, "If these papers are representative, it may be concluded that these are the biological topics most commonly presented in the public press . . . and since these types of biological

* EDITOR'S NOTE: The editor is of the opinion that newspaper articles cannot determine the basis for a course in science, the subject itself determines that. However, newspaper interests can point to desirable additions which could be made to the basic things, if time permits. The fundamentals for a course in science still are: To acquaint students with the great basic laws of an orderly world, and to develop a desire to apply scientific procedure and thinking to the problems of life.

J.E.P.

[1] Charles W. Finley and Otis W. Caldwell, *Biology in the Public Press*. New York: Lincoln School of Teachers College, Columbia University, 1923.

knowledge are going to the public in such large quantities, and over the whole country, they are thought surely to reflect genuine public needs and interests."

In 1924 a study was made by Curtis[2] to determine what sorts of scientific knowledge are demanded for an intelligent reading of the public press. The materials used in this investigation were the 2,153 articles clipped from newspapers by Finley and Caldwell in their study of biology in the public press, and 630 others of miscellaneous scientific content from six representative newspapers other than those used by Finley and Caldwell. These articles were analyzed and classified in the following ways: (a) the probable result or effect accomplished by the article, (b) the method of treatment of the materials, (c) the knowledge required to understand the article, (d) the source of the material, whether from the physical or biological sciences, (e) the topics included, and (f) the scientific terms used.

Significant findings of this study are:

1. Only 13.7 percent of the articles give scientific information and require no scientific background.
2. A very small number of the newspaper articles actually define scientific terms as a basis for further information contained in the articles; but more than half of those possessing scientific content contain scientific or technical terminology, an understanding of which is necessary for a full appreciation of the article.
3. Only 5.7 percent of the articles on the biological sciences require a foundation of technical knowledge as against 24.9 percent of those on the physical sciences.
4. There are about as many articles devoted to biology as to physical science.
5. A knowledge of theories and hypotheses is assumed in about 5 percent of these articles. Twenty-two of the 30 articles involve theories of biological evolution and heredity. . . .

In 1925 Hopkins[3] reported a study which he had undertaken to determine the scientific information needed for an intelligent reading of the daily newspapers and a selected list of magazines. The material he analyzed included the articles of a scientific nature in all the issues of four daily newspapers for a period of one month, and of the issues of alternate months for one year of two each of the following types of magazines: purely scientific, home, weekly, and farm. The list of magazines for analysis was

[2] Francis D. Curtis, "An Investigation of the Scientific Knowledge Demanded for an Intelligent Reading of the Public Press." In *Some Values Derived from Extensive Reading of General Science.* Contributions to Education, No. 163, Bureau of Publications, Teachers College, Columbia University, New York, 1924.

[3] L. Thomas Hopkins, "A Study of Magazine and Newspaper Science Articles with Relation to Courses in Science for High Schools." SCHOOL SCIENCE AND MATHEMATICS, XXV (November, 1925), 793–780.

determined by asking the pupils what they read; by examining magazine subscription lists to see what periodicals went into the homes of junior and senior high school pupils; and by checking the magazine sales of public newstands.

The findings of this study were:

1. Biology is distributed very evenly throughout all of the magazines. . . .
2. All sciences were distributed rather evenly throughout the newspapers . . . the biological material occupied on the average four times as much space as physical and ten times as much as chemical.
3. Biology is the most common branch of science occurring in the newspapers and magazines selected for examination.

As a result of this study Hopkins concluded that biology is the most important of all secondary school sciences from the standpoint of values for general education and that the topics which are of major importance in biology are Public Health, Animal and Plant Life, Foods, Natural Resources, and Evolution.

In 1926 Searle and Ruch[4] made a study to determine what scientific information the public pays for in standard magazines, and the relative amounts of this material devoted to the various sciences. An analysis was made of all the issues of eight popular magazines for the ten-year period, 1914–1923; five and one-half years' issues of a general magazine; and five years' issues of two purely scientific magazines. All of the articles which dealt with scientific materials and which met one or more of the following criteria, were clipped, read and analyzed. The criteria set up for the selection of scientific materials were these:

1. Does the article contribute to the background needed for an intelligent understanding of the principles, discoveries, and inventions of science?
2. Is the article in close relation to the interests of pupils in regard to science, and will it contribute to the satisfaction of the scientific interests of adults?
3. Will the article make a contribution toward a scientific attitude on the part of the reader?

The articles were classified by subjects and it was found that 62.2 percent of the articles were of a biological nature and 2.4 percent agricultural. The distribution of the major topics of the materials classified as Biology were: Man, 17.1 percent; Mammals, 10.5; Health, 9.2; Insects, 8.2; Disease, 7.2; and Food, 6.7.

In 1929 Merrill[5] reported an investigation which was made to

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[4] Albert M. Searle and Giles M. Ruch, "A Study of Science Articles in Magazines." SCHOOL SCIENCE AND MATHEMATICS, XXVI (April, 1926), 389–396.

[5] Amos N. Merrill, "An Objective Basis for the Determination of the Objectives and Materials for a Course in Botany for Secondary Schools," *Journal of Educational Research*, XIX (January, 1929), 31–38.

secure data that would serve as a basis for organizing a high-school course in botany to meet social needs. A tentative list of the basic human activities was set up. An analysis was then made of a selected list of publications such as magazines, official bulletins, technical journals, books and miscellaneous materials to secure data on groups of plants, or on specific plants, and on the human activities in connection with which the plants were mentioned. The data secured in the analysis were tabulated and the human activities were assigned to the "Plant Group" to which they were related.

The significant findings of this study were that the writers of periodical literature gave a relatively large amount of space to the food-producing groups of plants, and to the economic phase of plant life. The investigator concluded that "a course of study in botany for general training . . . must emphasize the economic phases of plant life," and "that there is need for shifting the emphasis in plant studies . . . from the lower to the higher forms of plant life, and for discussing these forms in their relations to human welfare."

In 1930 an investigation was made by Hill[6] to determine the biological content of non-specialized American magazines. The complete files, for the years 1921 to 1925, of nine magazines which specialized in no "particular fields of thought, and 'cater' to no special classes of people as teachers, ministers, farmers, mechanics, or scientists," were analyzed for biological articles and the total space in unit-column inches devoted to each topic, was determined.

The findings of this study show that the branches of biology, in order of descending importance as indicated by their emphasis in the articles of the magazines analyzed, were Animal Biology, Human Biology, General Biology, and Plant Biology.

In 1932 a study to determine the botanical materials found in selected magazines was reported by Garrison and Taylor.[7] An analysis was made of the issues of four general magazines for references which were botanical in nature. The three most important topics on the basis of the frequency of reference to them were found to be Flowers, Fruits, and Vegetables. Other topics which were frequently mentioned were Cereals, Forests, Breeding, Habitat, Budding and Grafting.

[6] Harry A. Hill, "A Comparison Between the Biological Content of Certain Periodical Literature and the Kansas High School Course of Study." *Science Education*, XIV (January, 1930), 430–436.

[7] K. C. Garrison and R. A. Taylor, "Botany Materials Found in Four Well-Known Magazines," *Peabody Journal of Education*, X (September, 1932), 87–91.

In 1932 Kutz[8] reported an investigation which was made to evaluate the extent and the nature of material on public health and hygiene appearing in selected newspapers. An analysis was made of the news, editorials, and advertisements in 240 different issues of three daily newspapers published during a period of 50 weeks, to secure all the articles and advertisements which had a "health implication." Each article was then assigned to an appropriate health topic according to the subject with which it dealt.

The important topics on the basis of the number of articles assigned to them were found to be Safety, Exercise and Fatigue, Communicable Diseases, Medicine and Surgery.

In 1937 Newland[9] reported a study which was made to determine the understanding necessary for reading allusions to science in current magazines. In this study an analysis was made of the articles and advertising material of 201 issues of four types of magazines; literary, home, story, and children's as evenly distributed as possible over the ten-year-period from 1921 to 1930.

A total of 2,420 different allusions to science, occurring in 24,022 contexts, was secured. The three most frequently emphasized allusions were made to Public Health, Food, and Household Appliances. Two percent of the allusions persisted over the ten-year period and those most frequently mentioned were also the most persistent.

In 1940 DeLoach[10] reported an investigation of the materials of a scientific nature that were presented in the articles appearing in all the issues of a popular magazine (*Life*) for the year 1940. The results of this study showed that a total of 56 scientific articles appeared during the year, forty-one of which dealt with the biological sciences. Medicine was found to be the most important topic, with 17 articles classified under it; zoology was next with 10 articles. The investigator concluded that "there was a definite tendency to lean toward the biological side, especially toward medicine, at the expense of such physical sciences as chemistry and geology."

In 1942 a study was made by Novak,[11] to determine the kind,

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[8] Sally E. Kutz, The Newspaper as Source Material in Health Education. Unpublished doctoral dissertation, New York University, 1932.

[9] Eveus Newland, "A Study of Allusions to Science in Magazines," *Science Education*, XXI (October, 1937), 126–130.

[10] W. S. DeLoach, "The Scientific Articles in a Popular Magazine," *Science Education*, XXV (October, 1941), 273.

[11] Benjamin J. Novak, "Science in the Newspaper," *Science Education* XXVI (October-November, 1942), 138–143.

amount, and rate of change of science material in a selected newspaper over a period of years. An analysis was made of all the issues of the *New York Times* for the years 1930, 1933, 1936 and 1939; a total of 1,461 issues covering an estimated 75,000 pages. Each reference to science "which met the subjective criterion of being material which was likely to be found in a science textbook or reference book," appearing anywhere in the paper, except in advertisements, daily weather maps, crop reports, and daily weather forecasts, was measured in column-inches. The references to science which were found were placed under 185 sub-topics, which were later classified under 15 major topics. Of these 15 major-topics 6 were biological in nature, namely; Health and Medicine, Animal Life, Man and Behavior, Gardening and Agriculture, Conservation, and Plant Life.

The findings of this study were:

1. Of the 15 major topics in science, Health and Medicine had the most space devoted to it; it averaged about one-fifth of all the space devoted to science.
2. The percent of space devoted to Gardening and Agriculture showed progressive increase; that devoted to Animal Life, and Man and Behavior a progressive decrease. No definite trends were found for the other major topics.
3. Approximately 50.5 percent of the newspaper space was devoted to biological science, and 49.5 percent was devoted to physical science.

In 1944 an investigation was undertaken by Martin[12] to determine the principles of the biological sciences which are of importance for general education. A tentative list of 300 major principles and 236 related minor principles was secured by an analysis of selected textbooks and research studies for biological principles. The principles were organized under appropriate topic headings and sub-topics. An analysis was then made of the materials in two years consecutive issues of 2 specialized magazines, *Hygeia* and *Nature Magazine*, of 2 non-specialized magazines *Life* and *Reader's Digest*. and in a random sampling of 24 issues of three selected newspapers for the period from 1929 to 1943. The issues were read and analyzed for materials for the understanding of which a comprehension of a principle, or principles from the major or minor lists might be considered necessary. For each statement, or statements, from any one article which were assigned to a principle in the lists, the princi-

[12] W. Elgar Martin, *A Determination of the Principles of the Biological Sciences of Importance for General Education*. Doctoral dissertation, University of Michigan, 1944. Published and distributed in microfilm form by University Microfilm, Ann Arbor, Michigan.

ple was arbitrarily assigned a frequency of 1. On completion of the analysis of all the sources used, the total of the frequencies of such asignments for each principle was computed.

A total of 2,620 statements (articles) from the magazine and newspaper materials analyzed, was assigned to 222 of the 300 major principles and the minor principles related to them.

The most important topic headings on the basis of the total frequency of assignment of statements (articles) to the principles under them were: 1. MORPHOLOGY AND PHYSIOLOGY, 642; with the sub-topics Materials for Growth and Replacement (Foods etc.) receiving 180, and Reproduction 173; 2. APPLIED BIOLOGY, 583, with the sub-topic Diseases receiving the total assignment of all these statements; and 3. ECOLOGICAL RELATIONSHIPS, 371, with the sub-topic Interdependence receiving 194 statements.

Summary

These research studies relating to the biological materials appearing in magazines and newspapers reveal definite agreements and trends in the findings which are of importance for the organization and presentation of the materials and learning experiences of biology for purposes of general education.

1. Biology is the most common branch of science occurring in the representative newspapers and magazines selected for examination in the studies, and if frequency of occurrence is an evidence of relative importance, it might therefore be regarded as the most important of all secondary school sciences from the standpoint of values for general education.

2. There is a marked agreement in the findings of the studies as to those areas which occur most frequently in the varied sources used. These topics, on the basis of their frequency of occurrence in the lists of the most important topics in each study are: Human Biology, Health and Disease; Animal Biology; Foods and Nutrition; and Plant Biology.

3. There is considerable evidence in the data secured in the later studies to substantiate the finding reported in the pioneer study by Finley and Caldwell, that " . . . the whole question of biology, so far as the public press is concerned, is *homocentric*, as [the] articles, either directly or indirectly, relate themselves to biology as it affects man."[13]

4. The close agreement among the findings of the different

[13] Charles W. Finley and Otis W. Caldwell, op. cit.

studies, in which different techniques and varied sources were used, indicates that the biological topics discussed in newspapers and magazines constitute a valid guide to the biological phases of science which are of consistently great interest because of their close relationship ot everyday experiences.

On the basis of all the data, therefore, the conclusion seems to be justified, that any reorganization of biology to serve the purposes of general education should be in the direction of a more functional treatment of the materials presented, and a greatly increased supplementation of the textbooks by the use of those materials related to the topics shown to be of importance in the studies surveyed. Until that time comes when an adequate treatment of these topics is given in textbooks in biology, teachers will find it necessary, either, to supplement the textbook with the biological materials appearing in current magazines and newspapers, or, to prepare source-units which contain the necessary materials.

SYNTHETIC RUBBER NOW FULL-FLEDGED ENGINEERING MATERIAL

Synthetic rubber is here to stay on its own merits, and it will no longer be used merely as a substitute for natural rubber, reports E. F. Riesing, chairman of the National Division of Rubber and Plastics of the American Society of Mechanical Engineers, and chief automotive engineer of Firestone Industrial Products Co., at a meeting of the ASME.

He pointed to the superiority of the synthetics in specific physical properties such as resilience, efficiency, low-temperature flexing, low-temperature brittleness, high-temperature stability, oil resistance, resistance to ultraviolet rays, ozone, acid, gas diffusion and other important properties.

The facts presented by Mr. Riesing were based upon extensive tests simulating temperature conditions in the African desert and in Alaska. One type of synthetic rubber, a polybutadiene compound, will not freeze or become brittle under substratosphere low-temperature conditions. This particular type of rubber freezes at 100 degrees below zero Fahrenheit.

ENGLISH COMES FIRST IN NEW U. S. PHARMACOPOEIA

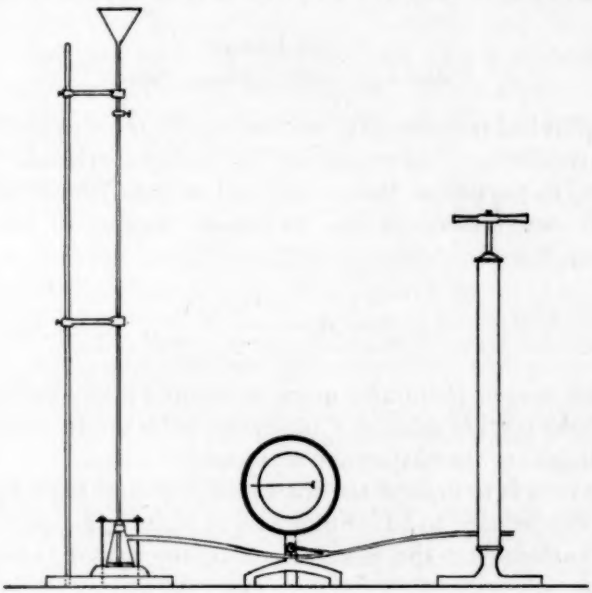
For the first time, the English language will take precedence over Latin in the U. S. Pharmacopoeia, the official compendium of drugs. After six years of discussion in the U.S.P. Committee of Revision, of which Dr. E. Fullerton Cook is chairman, it was decided that the new Pharmacopoeia, scheduled for publication in December, would carry the English names of drugs first, followed by the Latin. Medical members of the Committee were chief advocates of the change.

The U. S. Pharmacopoeia was first published in the 1820's, and has been published at ten-year intervals since. Recently, the Pharmacopoeia Committee decided a new issue should appear every five years, but it is understood that this decision may be reconsidered. Because Latin had been the language of science, it was used in drug and medical nomenclature.

A CONTROLLABLE DEMONSTRATION BAROMETER

HOMER W. LE SOURD
Milton Academy, Milton, Massachusetts

A mercurial barometer which shows the effect of increased or decreased pressure can be assembled from materials readily obtainable in a laboratory and shop, with the addition of one special piece of Pyrex glassware, a Filtering Flask with a side tube (125 ml capacity). The stand which supports the apparatus should have a broad, substantial base and a rod about three



feet high. A round metal plate, held in place by two bolts which extend through the base, serve to securely fasten the rubber stopper in the mouth of the flask. This is very necessary in order to prevent the stopper from being dislodged by the internal air pressure. Sufficient mercury is placed in the flask to make it certain that the bottom of the barometer tube is always below the surface.

The barometer is operated by pumping air into the flask while the stop-cock at the top of the tube is open. When mercury appears in the funnel the stop-cock is closed and one notes that the Bourdon gauge reads approximately 15 pounds per square inch.

The pump can now be disconnected and the mercury falls to the level of about 30 inches supported by the equivalent of about 15 pounds per square inch. When more pressure is applied by the pump or by the mouth the mercury level rises and with reduced pressure it is seen to fall. The experiment demonstrates clearly the principle of the mercurial barometer in a way that is impossible with the Torricelli experiment as it is usually performed.

HAVERSINES IN PLANE TRIGONOMETRY

LUISE LANGE
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In spherical trigonometry and its applications to problems of navigation several formulas for the oblique triangle become simpler, in particular better adapted to logarithmic computation, if one introduces the haversine instead of the cosine function,

$$\text{hav } A = \frac{1-\cos A}{2}.$$

For this reason more and more texts on Plane and Spherical Trigonometry are adding a haversine table, both natural and logarithmic, to the customary set of tables.

This note is to draw attention to the fact that these haversine tables can be used to advantage also in plane trigonometry.

(1) Introducing the haversine into the law of cosines one obtains

$$a^2 = b^2 + c^2 - 2bc(1 - 2\text{hav}A) = (b-c)^2 + 4bc\,\text{hav}A.$$

This formula has two advantages over the cosine law; (a) only two instead of three terms have to be computed; (b) in the case of an obtuse angle A, where the cosine law requires for the computation the substitution $\cos A = -\cos$ (180°-A), the haversine formula can be used without change. For the haversine (which changes from 0 to 1 as the angle changes from 0° to 180°) remains positive in the second quadrant, and its logarithm is directly taken from the table.

(2) From the above formula a very convenient expression is at once obtained for an angle in terms of the three sides,

$$\text{hav } A = \frac{a^2-(b-c)^2}{4bc} = \frac{(s-b)\cdot(s-c)}{bc} \quad \text{where} \quad s = \frac{a+b+c}{2}.$$

This formula as such is of course not new; it is found in several texts, both new and old (e.g. in Kells, Kern and Bland *Plane and Spherical Trigonometry*). These texts, however, arrive at the formula by way of the half-angle formula for sin $A/2$, which at once gives

$$\frac{(s-b)\cdot(s-c)}{bc} = \sin^2\left(\frac{A}{2}\right) = \frac{1-\cos A}{2} = \text{hav } A\,.$$

That means that they obtain this formula only late in the course, after the addition theorems and the double and half-angle formulas have been studied. As derived above from the transformed cosine law this convenient formula can be obtained and used right from the beginning in the computation of oblique triangles.

FIVE NEW WHITE DWARF STARS DISCOVERED

Five new white dwarf stars have been added to the list of known faint stars of high temperature and of a density so great as to be almost incredible, Dr. W. J. Lutyen of the University of Minnesota and Dr. Martin Dartayet of Argentina's Cordoba Observatory have reported to Harvard College Observatory.

This brings the number of known white dwarf stars to about 75. The newly-discovered white dwarfs are located in the southern constellations of Pavo, the peacock; Phoenix; Tucana, the toucan; and two are fairly close together in the constellation of Musca, the fly.

The stars were discovered when photographs taken with plates which were particularly sensitive to yellow light and those which were especially sensitive to blue light were compared. The plates were taken with the 60-inch reflecting telescope of the Cordoba Observatory.

PHARMACY COLLEGES AID MEDICAL RESEARCH

A total of 59 colleges of pharmacy, with nearly 300 faculty members and graduate students, are set to conduct medical and poarmaceutical research today, according to E. V. Lynn, chairman of the Committee on Pharmaceutical Research of the American Association of Colleges of Pharmacy.

Some colleges are already contributing in an adequate way, according to Professor Lynn who is also chairman of the Chemistry Department of the Massachusetts College of Pharmacy, Boston, "but our problem is to devise means for putting all of them to work efficiently."

In a letter to the Office of Pharmacal Information, Professor Lynn notes that firms with a specific pharmaceutical research problem are invited to bring it to the attention of his committee.

LIFE FOR THE STUDY OF LIFE

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Some time ago an article in SCHOOL SCIENCE AND MATHEMATICS discussed the importance of having living specimens in a biology laboratory. It is possible to house in a laboratory at least one or two representatives of each vertebrate phylum. Such living specimens are useful in more ways than one. First of all, the presence of living animals, well cared for, tends to arouse interest in life, a tendency which should instill into students a feeling of humaneness for the creatures of the earth, thereby lessening at least some of the cruelty often exercised toward the members of the animal kingdom. Secondly, since one of the objectives of science, with special emphasis on biology, is to develop the students' power of observation, that objective can be at least partially realized by the attention they give in class and out of it to the animals living their lives before them. Thirdly, oft times needless fear can be eradicated by the constant presence of animals in the laboratory. It even seems that a certain type of friendship may arise between the students and the pets whom they may be found watching with interest during a noon hour as well as after class.

Tropical fish and goldfish are good representatives of the Pisces phylum, though the former is more practical for the purpose of definite observation or study. The life of the guppies presents an interesting one to observe. Frogs and toads, the Amphibians, can be easily kept in a laboratory. As a member of the Reptilia group, the turtle will suffice. The melodious song of the canary as well as the beauty of that feathered friend certainly adds life to a laboratory. The albino or white rat can become a genuine pet. There you have the five phyla easily displayed in actual life before a class studying biology. Since biology is the science of life, why not display different types of life? The invertebrates are usually displayed by means of charts and preserved specimens, yet living material is also available. They are not, however, as easily cared for as are the higher classifications, the vertebrates.

During years of activity in a biology laboratory the writer cared for goldfish and guppies, frogs and toads, turtles, canaries, and white rats. Though hundreds of tropical fish were given to

neighboring school laboratories, the aquarium was at all times swarming with countless guppies. That school of fish certainly had a heavy registration. Though it has been said this type of fish devours its own, the writer tried to impress the students with the idea that the guppies in that particular laboratory were better trained. Just as that statement was made, however, a very observant student noticed one guppy, evidently poorly trained, feeding upon a dead member. One thing is certain that on two occasions on which the aquarium had to be emptied of its occupants because the aquarium had sprung a leak, very few dead guppies were found.

It was not unusual to hear the croak of a frog during a recitation or test period. At that moment the silence was broken by a chuckle here and there. One of the frogs used to sit for hours watching a nearby canary who so beautifully serenaded both frog and students. Frequently the students could have observed the unfolding of the frog's tongue as the bird flew from place to place in his cage. That act did not go unexplained. The students referred to the pair, frog and bird, as the girl and boy friend. Upon dissection of the frog at a later date, they were quite amused to find that the frog was truly a girl friend. Yes, animal life in a biology laboratory tends to enhance the study of the subject, for the students often referred to the laboratory as a "homey" place.

It was not unusual for the canaries, during their short period of freedom, to perch close to the students, unafraid of them. One can readily see that very useful lessons could have been learned by careful watching of fish, frog, and bird life.

The mammal representatives, the rats, teased the fearful girls a bit during their scampering moments. Invariably they attempted to climb up the stool on which the timid girl sat. The timidity finally disappeared as they slowly but surely became accustomed to the four-footed pets to such an extent that even they could have been seen near the rats' cage before class, during the noon hour, or at the close of the day. In a science class a distinction should be made between the albino pets and the alley rat. A laboratory table with its built-in sink is familiar to every science teacher. After school hours the rats often climbed to the table from which they jumped into the sink to take their daily shower. Often, too, they leaned over the edge of the sink to take a much desired drink, seemingly enjoying the taste of it better than the water provided for them in the cage.

Living animals, well cared for, should, therefore, be part of a biology laboratory. Students should be encouraged to observe their habits. There should be a purpose for the presence of animals in the science room. The value of vitamins in food can be taught by watching the rats' reaction to the food.

It may seem incredible that rats favor cleanliness. True, they tear paper into bits but observance will show this to be done to keep themselves as well as their young warm. The writer purposely took a baby rat from the mother. The students watched her search for it, take it back to her cage, and practically smother it with shreds of paper. Experience has proven that rats prefer a clean cage to a disorderly one. Give them their freedom, clean their cage, and you will find that at the rustling of fresh paper they will scamper towards the cage from whatever corner they may have wandered.

Living specimens certainly have their place in a biology laboratory but, of course, they must be given proper care. Cleanliness of their little homes is essential not only because of the pets but also because the health of the students demands the consideration of the teacher.

MINING AND METALLURGICAL AWARDS GIVEN

The James Douglas gold medal of the American Institute of Mining and Metallurgical Engineers was awarded to Dr. Robert Franklin Mehl, director of the metals research laboratory of the Carnegie Institute of Technology, Pittsburgh, and head of its department of metallurgical engineering.

The medal, established in 1922, was given Dr. Mehl "for distinguished achievement in physics and physical metallurgy; and especially for his development of gamma-ray radiography and for conspicuous success in his metallurgical investigations involving diffusion and crystal structures."

For improving the process of making Bessemer steel, the Robert W. Hunt Silver Medal and Certificate for 1945 was granted E. Chester Wright, chief metallurgist of the National Tube Co., Pittsburgh. The particular type of steel with which Mr. Wright worked is used in making seamless steel tubes, especially the type of steel pipe used in transporting oil, as in the "Big Inch" pipe line.

The J. E. Johnson, Jr., award was granted Carl Gustav Hogberg, assistant to the chairman of the Blast Furnace Committee of the U. S. Steel Corporation "for his contributions to the science and art of smelting iron ores in the blast furnaces," it was announced at the meeting of the board of directors.

For research work leading to the improvement of methods of production of brass cartridge cases, William Marsh Baldwin, Jr., chief metallurgist of the Chase Brass and Copper Company, Euclid, Ohio, was given the 1945 award of the Institute of Metals Division (A.I.M.E.).

CAREERS IN SPECIAL LIBRARIANSHIP

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"Although there are innumerable possibilities the Special Libraries Association has hesitated to work for the formation of new libraries because of the lack of this trained personnel. That is why the association feels so strongly that our training agencies should be interested in understanding this need and meeting it —thus providing employment for many capable people."[1]

This statement was made by Miss Savord in 1941 and is even more true today. The war effort has created, either directly or indirectly, many special libraries, libraries which, in most cases, will not cease to function with the end of the war, because they have sold themselves to their companies or their clientele through their intelligent and efficient service.

This field of special librarianship is not crowded; in fact, positions are waiting for the capable and intelligent subject specialist who has a flair for books and a hidden desire to be a detective, to ferret out buried or disguised information, and to build up a workable and usable collection of materials of all sorts, from books and slides to microfilms and laboratory research reports.

In what other career does one have the opportunity to combine the above qualifications with initiative, personality and administrative ability? Special librarianship offers a student with these qualifications an interesting and challenging career, a chance to work with keen minds, outstanding figures in the field, and an opportunity to follow the latest research—sometimes to anticipate the trend of future research.

The subject field of special libraries is wide and varied and growing larger every year. I should like to tell you about a few of the more unusual types.

The motion picture industries have large research and reference libraries. Their staff members have the tremendous job of checking on the authenticity of costumes and background in all historical and social pictures. An immense amount of research goes into every motion picture and the resources of these libraries include, besides books and periodicals, clipping files,

[1] Savord, Ruth. "Training for Special Librarianship." American Library Association. Bulletin. *32*, 910–14 (1941).

picture files, a collection of license plates from many states, menus, bills, newspapers and films, both pictorial and news.[2]

A new type of library has recently been organized by the United States government—the United States Information Library. Such libraries have been or are being set up in many of the Allied Nations. They serve our embassies and legations, the foreign governments of the country where they are located, journalists, other libraries and "anyone who has a question which can be answered from American publications."[3]

Because maps are so important to the army in planning the campaigns of this war, the United States government has set up a Map Library and culled maps from many sources all over the United States.[4]

For the student who is vitally interested in fashion designing there is the Fashion Sketch Collection in the Brooklyn Museum Library, Brooklyn, N. Y., which has in its files original sketches by such outstanding designers as Alix, Patou, and Chanel and many well known American designers.

Many railroad companies have libraries which serve the technical and research staffs, the business departments, the executives and which provide recreational reading for the employees.

Scientific research organizations, universities, and research foundations usually have large specialized libraries whose collections of research materials cover all divisions of the natural sciences.

Organizations whose research is predominantly chemical in nature are quite numerous. The librarian must understand the subject matter in order to serve the patrons; a knowledge of languages is essential, for the literature of chemistry is world wide and all of it must be covered by the chemist in his literature and patent searches. Weekly abstract service covering the most recent periodical literature is often required of the chemical librarian.

There are many other types of special libraries: Newspaper, insurance, financial, transportation, art, and music, to name a few. The field is almost inexhaustible; in fact, there will be an end only when librarians stop proving that their efficient methods and understanding of the special field pay dividends.

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[2] Wilkins, Eleanore E. "Motion Picture Research Departments." Special Libraries *35*, 46–51 (1941).
[3] Williams, C. S. "U. S. Information Libraries." Special Libraries *35*, 170–5 (1944).
[4] Masten, F. E. "The Army Map Service." Special Libraries *35*, 83–88 (1944).

Because most of these libraries are so specialized and because they usually serve a clientele composed of persons who are specialists the librarian must be a subject specialist; she must speak the same language as her patrons; she must be so familiar with the research materials within her library or even nearby libraries, that she can pick out the fundamental idea or question within a request and ask intelligent questions of the patron, when his request is stated in broad generalities.

Preparation for such careers may begin as early as high school; in fact, it might better begin at this level to enable the student to acquire a broad general knowledge, and fluency in several languages.

A natural interest in the sciences is essential for a student choosing a career in the scientific library field, but at the high school level it is unlikely that he will be able to decide upon one particular science. In many ways this is best, for in the course of the usual sampling a varied and often useful array of facts may be obtained. Basic facts and terms peculiar to one science often prove exceedingly useful to a librarian tracking down a reference question with only a minimum of clues.

A good course in general science, if taken early in a high school program, may often be sufficiently stimulating in the several basic sciences to enable the student to determine the one in which he will major in college. Once he has made his choice he will be able to eliminate all extraneous courses from his college curriculum. Allied sciences will naturally find a place in this program. Languages, as mentioned before, are essential, but the basic knowledge can be obtained in high school, saving college time for courses not available in the usual secondary schools.

A one year course in library science should follow the Bachelor's degree. Many library schools are cooperating with scientific departments on the same campus and the student is able to combine graduate courses in a subject field with his library degree. In this way, he may prepare himself more adequately for specialized work.

The genius of American democracy is expressed in the traditional independence and freedom of our State and local schools and school systems. Their freedom of action for educational purposes must be preserved. It is upon that freedom that we hopefully depend for assurance that the judgments of our people will be soundly based.

—Franklin D. Roosevelt.

SCIENCE—MATHEMATICS—INDUSTRY

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Industry has always needed men possessed of industrial experience and technical education. The lack of competent mechanics—as well as engineers, chemists, scientists and others having technical training and experience has been one of the major problems encountered by industrial management during the past few years.

Education has had a general but not too clear an appreciation of this problem. The reason for this condition was the fact that the majority of high school counselors had never worked in industry and were therefore little better prepared to counsel the boys and girls in the secondary schools regarding industrial jobs than the boys and girls themselves.

Many educators have a sincere desire to be better qualified, in the terms of effective counseling, so that their students may more efficiently serve in the technical industrial fields. But more than sincerity is needed. Actual job experience and training must be gained in some manner.

A study of the counseling situation reveals that there is a general agreement that the "market is frightfully short" of teachers and counselors having a background of practical scientific and industrial experience. The wide-spread criticism of the public schools has brought to educators a comprehension of the inadequacy of recent high school graduates. Much of this criticism has been directed toward high school graduates who have been entering both the armed forces and industry.

These high school youngsters need counseling and help—and those who remain in school need the same—but please remember that counselors cannot be created overnight. The mere giving of the title of counselor to an individual does not give to that person the ability and right to counsel boys and girls. Is it possible to remedy this situation? One of the best solutions so far suggested is the one in which experienced teachers would be given, during the regular summer vacation months, the opportunity of working at a factory job.

Merely to have undergone working experience in a factory is not the entire answer. The attempted solution appears to be providing educators with directed practical and useful factory experience. The Chrysler Apprentice School of Chrysler

Corporation has attempted to meet this need. During the summer of 1943—and again during the summer of 1944—this corporation arranged during each of these summers for ninety teachers (men and women), college deans, professors, and counselors, to learn how to operate factory production machinery—and thus to gain an intimate knowledge of factory operation and life.

The plan of procedure included not only the factory work experience but also a series of group conferences, held on company time, dealing with many of the more important industrial management and guidance problems.

The plan has attracted wide and favorable attention. Several leading universities now have a participating interest in the "Chrysler Teacher Plan"—and arrangements are made so that teachers may earn money and university credits at the same time.

The conferences, which are an important and regular part of the program and were lead by top industrial administrators, have enabled teachers to gain a true and first hand appreciation of industrial problems which could have been acquired in no other manner.

The conference topics for the 1944 summer session were as follows:

1 Orientation to Chrysler Corporation
2 Factory Safety
3 Measurement in Industry
4 Chrysler Tests
5 Industrial Machine Tools
6 Industrial Metal Cutting Tools
7 Surface Finishing of Metal
8 What is Chrysler Corporation
9 Interpretation of Engineering Drawings
10 Personnel Procedure
11 Technical Training
12 Production Methods
13 Supervisory Training
14 Industrial Relations
15 Shop Mathematics
16 Engineering Methods
17 Advertising Methods
18 The Master Mechanic's Work
19 Public Relations
20 Chrysler Guidance Program
21 Development of People and Products
22 Sales and Economic Trends
23 Industrial Medicine

Additional conferences were under the direction of the participating universities.

Among other things the teachers learned through taking part in these conferences was that many industrial leaders, as well as educators, feel that *if the fundamentals in science and mathematics are thoroughly taught in the grades and high schools that industry will be able to teach quickly the practical and specialized application of this knowledge so as to best meet industrial requirements.*

It has been pointed out very often that "our modern educational approach does not sufficiently differentiate between education and training. It tends to put undue emphasis upon training to the neglect of real education." The teachers engaged in this factory work experience found much evidence that there was a real need for mastery of principle fundamentals rather than school training in routine performance.

Just what are these fundamentals in science and mathematics which should be thoroughly taught? Many of us would like to have the answer to this question.

Ninety educators, after a summer of factory working experience and conferences, were considered as being in a position to offer expert opinion as to what science and mathematics fundamentals are needed in industry—and should be taught in our schools. In order to obtain such expert opinion these ninety teachers were asked to answer a number of questions. The answers to these questions were given willingly—and are interesting.

The questions were presented to the teachers through the use of the following questionnaire. Following the list of questions is a summary of the opinions. Sixty-nine of the teachers returned the filled-out questionnaire.

QUESTIONNAIRE

What fundamentals of science and mathematics should be taught boys and girls at the high school level?

During eight weeks of the past summer, the ninety educators in this group (Chrysler Corporation) have learned to operate several different kinds of machines. You educators have had actual experience in factory work. Because you do have an educational background and teaching experience, plus the factory experience you have gained during the summer employment, we are coming to you for help. We would like to have your assistance relative to the question heading this questionnaire.

In handling this work, will you please consider the following suggestions:

1. Please do not sign your name to the questionnaire.
2. While most of the questions may be answered through the use of check marks, we would appreciate your comments.

Question I

Knowing that the great majority of your high school students, when they reach adulthood, must earn their living and that many expect to be employed in the industries, what science or sciences do you believe they should take while in high school? (Below have been listed three high school sciences. Cross out sciences not needed and add the names of sciences you feel the students should take before being employed in industry.)

1. Physics—One Year
2. Chemistry—One Year
3. Biology—One Year
4.
5.
6.

Question II

In order to earn a living through being employed in industry, what courses in mathematics should your high school students be encouraged to take? (Below is a list of four courses in high school mathematics. Cross out courses not needed and add the names of courses you feel that high school students should study before entering industry.)

1. Arithmetic
2. Algebra
3. Plane Geometry
4. Solid Geometry
5.
6.
7.

Question III

What specific items should form the content of the courses in high school mathematics? Should the secondary school mathematics program include the items listed below? (Cross out those items you feel that the student does not need as a part of his preparation for entering industry. Add any specific items you know should be included in this list.)

1. Decimal Fractions
2. Common Fractions
3. Percentage
4. Blueprint Reading
5. Measurements—Arithmetical
6. Square Root
7. Algebraic Addition & Subtraction
8. Transformation of Formulas
9. Algebraic Multiplication & Division
10. Solution of Equations
11. Simultaneous Equations
12. Quadratic Equations
13. Geometric Constructions
14. Areas of Geometric Figures
15. Volumes & Surfaces of Solids
16. Trigonometry—Tangents, Cotangents, & Cosines
17.
18.
19.
20.

Question IV

What specific items should make up the content of an acceptable course in high school chemistry? Should the secondary school course in chemistry include the items listed? (Cross out those items you believe would not be required as a part of the student equipment on entering the employment

of an industrial organization. Add any items you know should be included in this list.)

1. Physical & Chemical Changes
2. Valence: Chemical & Energy Changes; Equations
3. Oxygen & Hydrogen—With the Processes of Oxidation & Reduction
4. Water—Its Necessity & Usefulness in Life
5. Solutions & Colloidal Dispersions
6. Acids—Bases & Salts
7. Ionization
8. The Atmosphere & Non-Metals
9. Introduction to Organic Chemistry
10. Carbohydrates, Fats, & Proteins
11. Digestion of Foods
12. Vitamins & Endocrine Secretions
13.
14.
15.
16.
17.

Question V

What specific subject matter should make up an acceptable course in secondary school physics? Should this course include the items listed below? (Cross out subject material you believe would be of little value to the individual entering industry. Add any items you feel should be included in this list.)

1. Matter & Mechanics
2. Molecular Physics
3. Force & Motion
4. Work, Power, Energy
5. Machines
6. Heat
7. Sound
8. Light
9. Magnetism
10. Static Electricity
11. Current Electricity
12. Radio & Radiations
13.
14.
15.
16.

Question VI

This question deals with the methods used in science teaching. Many educators will object to it being included in the questionnaire. It is offered because the method used in presentation of science subject matter often determines its value to the student. Should preference be given by the science instructor to individual laboratory work or to the teacher demonstration method?

Question VII

Have we been devoting too much time and energy teaching about the practical applications of the sciences and mathematics before teaching thoroughly the fundamentals and principles?

Question VIII

What physical manipulative skills (for example, carpentry and bricklaying) should the secondary schools attempt to teach?

1. 3.
2. 4.

Question IX

Would you recommend that science and mathematics teachers take part in a program of directed factory work and experience as a portion of the preparation for teaching?

The following is an attempt to summarize the answers to the questions, along with the comments made by the teachers..

QUESTION I

One year of high school physics should be required 47
One year of high school chemistry should be required 42
One year of high school biology should be required 30
In four year high schools one year of general science should be required 22
Aeronautics—amount of time to be devoted to subject not given 3
One year of physical science should be required 3

Teacher comments:

"We believe that if a student would take all of the science and mathematics courses indicated in this study he would be much better prepared to do industrial work intelligently. The more of these subjects he takes the better his chances for promotion. However, a person could work on many simple machines without having had any of these subjects."

"Students should be encouraged to take chemistry only if it is taught as pre-industrial chemistry."

"In the skilled industrial trades continued use will be made of all of these sciences."

"Unless the worker advances beyond the average industrial worker level he does not need any of the sciences named. If he does advance beyond this point we believe that physics is most needed."

It has been my experience and observation that boys will not complete science courses in school unless they are preparing for some special occupation. This requires parent direction and encouragement."

Question II

Out of a total 69 replies we find the following:

1. In four year high schools, and in other high schools if possible, one year of arithmetic should be required... 48
2. One year of algebra should be required..... 53
3. One year of plane geometry should be required..... 46
4. Solid geometry—majority recommended one year be required..... 32
5. Trigonometry—time one semester—should be required 26
6. Shop mathematics—very few of the teachers suggested the amount of time to be devoted to this subject..... 20
7. Commercial arithmetic..... 12

Question III

1. Accepted the list without change..... 42
2. Modify the list..... 19

The suggested additions to be made to the list were:

Add many practical problems. Give plenty of time to ratio and proportion. Study logarithms and graphs. After the war we need to have a thorough understanding of the metric system —include it.

Many teachers wished to eliminate the study of trigonometry and blueprint reading from high school mathematics.

Question IV

This question brought forth several very interesting comments.

Accepted the list without change..... 38
Would modify list..... 23

Many of the teachers would eliminate from the chemistry course the material dealing with organic chemistry, digestion of foods, and vitamines and endocrine secretions. Several thought these items should be studied in biology rather than in chemistry.

Suggested additions to the list included metals, dyes, fuels.

Question V

Accepted list without change..... 40
Would modify list..... 17

Several teachers would like to devote time to a study of precision instruments. Seven teachers thought it would be a good idea to add a third semester to the present high school physics course.

Several persons suggested that the portions of physics dealing with radio and radiations be eliminated. Four teachers would delete the study of musical instruments.

Comment by one teacher:

"Physics is for boys and girls headed toward something more than jobs as machine operators."

Question VI

This question created interest. It brought forth replies from 64 out of the total of 69 teachers returning the questionnaires.

1. Preference for individual laboratory work..... 36
2. Preference for teacher demonstration..... 17
3. Combination of the two methods..... 11

Question VII

1. Yes..... 36
2. No..... 17

Comments:

"We have been spending too much time teaching about things —and not enough about how to get these things done."

"The trend toward what has been called soft pedagogy has gone beyond the bounds of good educational practice. Thorough knowledge of fundamentals and principles is essential to a good understanding of the practical application."

Question VIII

1. General machine shop..... 30
2. Mechanical Drawing..... 26
3. General Electricity..... 16
4. General Shop..... 7

Question IX

1. Would recommend taking part in such a program..... 66
2. Program of no value..... 1

Comments:

"Excellent experience because there is too little realistic experience in the average teacher's background."

"This plan is excellent if the teacher is given diversified experience but placing him in one place as a machine operator and

not allowing him to see different parts of a factory would make the experience valueless."

"Science and mathematics teachers should all take part in a program of directed factory work and experience as a portion of the preparation for teaching. The experience would certainly be broadening in its effect on teaching. The factors to be considered are: "What kind of factory work? How much? Under what conditions?" Believe values almost as great for teachers of other subjects as for science and mathematics. Would give also an appreciation of the social and economic conditions in industry."

Conclusions

The general comments of those contributing to this study make it clear that the level of work the individual is to perform in industry determines the value of the courses in high school science and mathematics to both the individual and to industry. The question presented is this: Is the individual who enters industry to advance rapidly or is he to simply work at a machine? Those taking part in this study infer that the average individual ends up by working at machines doing very routine work with very little opportunity for advancement. A few advance and reach top positions. Many of these teachers state in a very definite manner that the average worker does not need to know about science and mathematics because any average person can be taught in a very short time to run a machine successfully.

On the other hand there is general agreement that the person who does make real advancement must have a thorough knowledge of the fundamentals of mathematics and science.

Many of these teachers believe that there is nothing fundamentally wrong with our present science and mathematics programs except that we do not teach the fundamentals well. Many of these educators claim therefore that the solution lies in the demands of fathers and mothers and industry that children be taught well the fundamentals and thus be prepared for the rough going out of which life is really made. Apparently the learning of organized facts and learning by doing must displace much of the pampering process now in vogue.

These teachers feel that it would be a good thing for all science and mathematics teachers to have actual experience in industry so as to learn first hand, and thus may better understand the need for teaching fundamentals.

LIARS AND STATISTICIANS

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Who was it who first paraphrased Mark Twain with the statement that there are liars, damned liars, and statisticians? Perhaps it was the same cynic who coined the bromide that figures cannot lie but liars can figure. Both these witticisims belong in the category with jokes about doctors who bury their mistakes, for it seems to be a fact that we are prone to regard figures, and propositions which can be proved by figures, with the same naive credulity with which we regard medicine. And when we find that the same set of figures can be used to support the claims of both opponents in an argument, we feel that we have indeed been fooled.

It will be the purpose of this paper to point out some instances of misuse, misinterpretation, and perversion of statistics. Many of the examples from the field of economics are taken from a paper by Jerome B. Cohen which appeared in the *Journal of the American Statistical Association* for 1938.

Yule's *Theory of Statistics*, which has gone through eleven editions and is still the mathematical statisticians' bible, defines statistics as quantitative data affected to a marked extent by a multiplicity of causes, and statistical methods as methods specially adapted to the elucidation of such data. Statistical methods may be classified in various ways. A classification along functional lines of methodology subdivides statistical theory into the theory of sampling, which studies the extent and reliability of conclusions about an original source which can be drawn from a sample; correlation theory, which studies the nature and degree of relationship which exists between two or more attributes; and dispersion theory, which treats of inferences which can be drawn from sets of samples concerning the homogeneity of the source from which the samples were drawn. A topical classification on the basis of fields of data would subdivide statistical methods into those particularly useful in biology, economics, insurance, education, physics, astronomy, and various branches of business. The present paper will not attempt to follow either classification, but will confine itself to pointing out spectacular instances of misuse in different types of methodology as applied to various fields of data.

Great strides have been made during the past thirty years in the development of statistical theory and in its applications. Earlier development was handicapped by the fact that the statistical data available were often fragmentary and unreliable, and that such data as were available were frequently not comparable. With improved facilities for gathering and classifying data, statistical methods have been improved; but with the greater employment of statistical data in contemporary debate, opportunities for partisans to pervert statistics to their own purposes have also increased.

One glaring misuse of statistics is the comparison of figures which are not comparable. On June 2, 1938, a pro-New Deal evening newspaper in New York carried the following headline and lead on its financial page:

Electric Output in Seasonal Rise

Electric power production for the week ending May 28 rose substantially above the total of the previous week. . . .

The next morning an anti-New Deal paper carried the following dispatch:

Power Output Off 10.6% from 1937 Figures

The production of electricity in the United States in the week ended May 28 was 1,973,000,000 kilowatt hours, a drop of 10.6% from the 1937 week according to the Edison Electric Institute.

The words "previous week" in one dispatch and "1937 week" in the other reconcile the apparent contradiction, but the average layman who read both items must have been puzzled and confused, and he who read only one could easily have been misled. Relative numbers derive their significance from the base in terms of which they are expressed, and by properly choosing his base, the propagandist can make the figures prove his point.

The results of statistical investigations, stated in numerical form, are, in the public mind, assigned a degree of definiteness usually associated with mathematical technique. However, these results are usually based on the study of a sample, drawn from a larger universe of data, and the numerical conclusions derived from the study of the sample may not accurately reflect the larger universe unless the sample is an accurate cross-section of the universe. Whether the sampling bias is deliberate or unconscious, it results in a misuse of statistics.

The classic example of biased sampling was the 1936 *Literary Digest* poll, which predicted Landon's election. Although over

ten million ballots were mailed out by the *Digest*, the mailing list was compiled from telephone directories and automobile registrations, and a definite bias in favor of high income, anti-New Deal opinion was introduced. The polls conducted by the American Institute of Public Opinion and *Fortune* magazine utilized much smaller samples but selected them carefully to include all economic groups in the proper proportions, and were much more accurate.

A bias may result from the most unexpected sources. A check on a census study of the size of families in a certain district showed that the samples indicated larger households than were actually typical of the district. The samples were representative as to race and economic status, but it was discovered that the enumerators had failed to revisit all families not at home when they first called. Since the larger the family, the greater the likelihood of someone being at home, and since childless married women are more likely to be away on a business or social errand, definite bias in favor of large families had been introduced.

A census taken in China a few years ago for poll-tax and military purposes revealed a population only about a quarter as large as that taken a few years later for famine relief. Our census contains many more women between ages of eighteen and twenty-five, and many more Southern negroes of amazingly old age than exist in real life.

The very improvements in coverage and classification which enhance the value of statistics may result in misrepresentation when data compiled at different times are compared. Some years ago a fear of negro domination swept the country. Census returns showed that negroes had increased more rapidly than whites between 1870 and 1880. The explanation was that the latter census was much more efficient in enumerating Southern negroes than the former, but it was difficult to stem the tide of propaganda.

An 8% increase in the death rate from syphilis in New York state in 1937 as compared with 1936, in spite of the fact that a campaign against the disease had been waged that year, did not necessarily mean that the disease was increasing. Doctors are less reluctant to attribute death to syphilis than they formerly were, and a check on death certificates in which "heart disease" or some other euphemism was given as the cause of death might have shown a decrease.

Many more instances of misuse of statistics caused by the

comparison of data which are not comparable, biased sampling and changing definitions and classifications might be cited.

Another source of misrepresentation arises from the misuse of percentages. In a speech delivered by James J. Davis the following statement was made: "Fifty-three thousand American soldiers were killed or died of wounds during the nineteen months of our participation in the War, victims of every refinement of modern slaughter, yet during the same period 130,000 persons, more than twice as many, were killed at home in the performance of tasks of peace." If the percentage of deaths to the total exposed to death in the trenches had been compared to the percentage of deaths to the total exposed to death at home, the implication would have been far different. This is a case where the use of actual numbers instead of percents is misleading. On the other hand, the use of percentages instead of actual numbers may give a distorted picture, as when, a short time after Johns Hopkins University opened courses to women, it was reported that $33\frac{1}{3}\%$ of the graduates had married into the faculty. Investigation showed that three women had graduated.

To compare percentages of different bases is almost always misleading. It might be true that during a year the number of horses on the streets of a community had increased 100% while the number of automobiles had decreased 10%, but if, at the beginning of the year, there had been one horse and 1000 automobiles, the year's end would see two horses and 900 automobiles, and the picture of civilization's progress would be considerably less bleak. Index numbers based on 1929 figures present a far different picture of current trends than those based on 1933 figures. In the 1936 campaign, Republicans could maintain that food costs had jumped 40% in three years, and Democrats could counter that they were 20% below the 1926 level, and both could be correct, to the confusion of the ignorant voter.

An average is a measure of central tendency, a single number which is regarded as characteristic of the entire mass of data from which it is derived, a typical number. But a typical number which is not typical, or a number which implies a central tendency which does not exist, may be misleading. Advocates of a managed currency at one time pointed out that the index number of prices (which is in a sense an average price) in Sweden had been remarkably stable. However, this stability was due to the combination of rising prices of imported goods with falling prices of agricultural products grown at home. Thus the stable average

did not typify the behavior of its component parts.

Sometimes the use of a single number to typify an entire distribution conceals significant features of the distribution. It has been argued that foreign trade is unimportant to our national economy since in normal times our exports do not exceed 10% of our annual production of goods. However, our exports of cotton, tobacco, wheat, and a number of other commodities are considerably in excess of 10% of the quantities produced, and the loss of foreign markets for these commodities would involve more readjustment than the 10% figure would indicate.

Finally, an average may indicate a tendency which is not true of any of the component parts from which the average is formed. It would be possible for the average wage of a group to increase while the wage of each individual in the group decreased. Assume that a factory employs 1,000 workers, 200 of whom are foremen who receive $50 per week while the remaining 800 receive $20 per week. The average wage is then $26 per worker. Some crisis causes the laying off of 600 of the workers. The 200 foremen are retained, but the wages of all are cut 20%, giving the 200 foremen a weekly wage of $40 and the workers $16. The average weekly wage is now $28 instead of $26, in spite of the 20% reduction. This is, of course, a manufactured example, but it illustrates the manner in which an average may be distorted. An average is a powerful and indispensable tool in statistical investigation, but even an average may backfire.

Of all statistical measures, perhaps the correlation coefficient is most liable to misrepresentation. The coefficient of correlation is an abstract number, varying in value from -1 to $+1$, calculated by a definite mathematical process. Its magnitude indicates the degree of relationship which exists between two variables. Its interpretation "abounds in pitfalls easily overlooked by the unwary, while they are cantering gaily along upon their arithmetic." Errors in the use of correlation technique arise when correlation due to pure chance is held to be significant, or when the existence of a high degree of correlation is interpreted as evidence of a causal relationship.

As an example of the first type of error, bank clearings, in billions of dollars, in the years 1883, 1893, 1903, and 1913 have been correlated with the compound amount in each of these years of a principal of $1 invested at 5% in 1883. The correlation coefficient obtained was .999, indicating almost perfect correlation, yet the relationship between these two variables could

be attributed to nothing but mere chance. Variations in the death rate in a city in India from 1911 to 1919, when correlated with variations in the membership of the International Association of Machinists for the same years, showed a high positive correlation of .86, but certainly demonstrates no cause and effect relationship.

However, where a relationship is within the realm of logical possibility, and where for the purposes at hand a demonstration of causal relationship is desired, a positive correlation will probably be so interpreted. Yule points out that English statistics reveal three trends: the proportion of marriages contracted outside the Church of England has been increasing, the average age of Britons at death has been increasing, and the divorce rate has been rising. A positive correlation exists between the increase in the proportion of marriages contracted outside the Church of England and the increase in the average age of death, yet no one supposes that there is a causal relationship and that a law prohibiting the solemnization of marriages in churches would have the effect of improving the longevity of the nation. However, a Church of England publication points to the correlation between the increase in the proportion of marriages contracted outside the Church and the growth in the divorce rate and holds the former to be the cause of the latter. If this correlation were considered alone, the assumption of the causal relationship might appear logical, but is it any more logical than the assumption that because there is a positive correlation between the growth in the divorce rate and the increase in the average age of death, the increase in the average age of death may be attributed to the diminution in the nervous strain and the increase of peace of mind resulting from greater ease in eliminating a nagging spouse?

So perfect correlation between two variables does not necessarily imply more than a chance relationship between them; certainly a cause and effect relationship cannot be established solely by the magnitude of the coefficient of correlation. But this is not the worst of the picture. The coefficient of correlation measures only one type of relationship between two variables, a linear relationship or direct proportionality. There might exist a close relationship between two variables, in fact one might be a function of the other, but unless it were a linear function, the coefficient of correlation would not show this relationship. For example, the distance fallen by a body acted upon by gravity is

a function of the time it has fallen, and the relationship is given by the equation $d=\frac{1}{2}gt^2$, but if we were to correlate distances fallen with the corresponding times of descent, the coefficient of correlation would not be close to the desired unity. Here we have distance varying with the square of time, not with its first power, and the coefficient of correlation is not designed to measure this type of relationship. There is another statistical yard stick, the correlation ratio, which is adapted to measuring this type of relationship.

The statistical worker who feeds his data into a formula like meat into a sausage machine without knowing what makes the wheels go round, and then assumes that his conclusions have been proved mathematically, may bring statistical theory into disrepute temporarily, but in the long run he discredits his own field of investigation.

As a final exhibit, I give you probable error, another statistical term which is widely misused and misinterpreted. It started life handicapped by its name, which seems to imply that probably an error has been made in calculation and probably it was of a certain size. This is not at all what the term implies. If we calculate the probable error of the mean of a sample by the formulas which amateur statisticians quote glibly, we obtain the deviation from the mean which we are just as likely to exceed as to fall short of when we calculate the mean of another sample drawn from the same universe. The probable error is not an error in the usual sense, it is a deviation, and not even the most probable deviation. "Equally likely deviation" would be a more appropriate name for it than probable error. There is a further pitfall. The formulas ordinarily used for computing probable error assume a normal distribution of items, a situation seldom met in practice. Certainly when one affixes a probable error to his results, he has not always considered how closely his data conform to a normal distribution. It seems likely that the more modern method of expressing the reliability of a statistical estimate in terms of fiducial limits will replace the traditional but often misleading mode of expression involving probable error. Using fiducial theory, precise statements can be made in terms of probabilities about the bounds within which a variable lies without making an assumption about the initial distribution of possible values of the variable.

The moral of this tale can perhaps be most succinctly stated by quoting from Karl Pearson's *Grammar of Science*. "It can

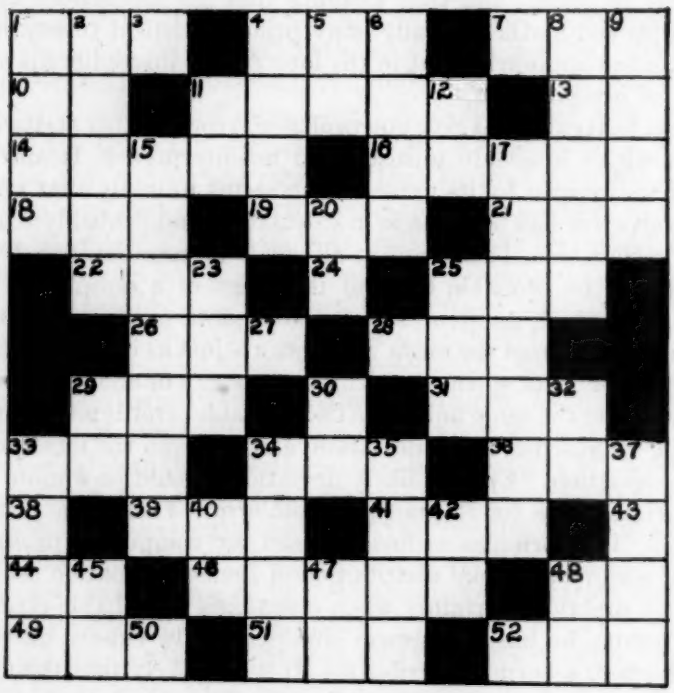
scarcely be questioned that when the truth or falsehood of an event or observation may have important bearing on conduct, over-doubt is more socially valuable than over-credulity."

CROSS-FIGURE PUZZLE

JESSIE R. SMITH

Technical High School, St. Cloud, Minnesota

Contributed by Celius Anderson and Robert Lillistrand, Mathematics Department, Technical High School, St. Cloud, Minnesota.



CROSS-FIGURE PUZZLE

HORIZONTAL

1. The cube of 5.
4. Naval compass reading for Southwest.
7. Height, in feet, of a military objective one mile away, if the angle of elevation is 1°33′43″.
10. A man had 25 sheep. If all but 12 died how many did he have left?
11. The mantissa of the logarithm of 2.745.
13. 73⅓ ft. per second, is how many miles per hour?

14. (Reciprocal of 2.83) $-.000022$.
16. $(3\times13)^3$.
18. One more than the number of degrees in a straight angle.
19. 15 minutes past the hour that is one-third of the time between noon and mid-night.
21. A number whose three digits are equal.
22. Sin 20°.
24. The smallest number of planes needed to fly in a formation of 2 planes ahead of a plane and 2 planes behind a plane.
25. Evaluate $2x(16x+5)+3$, if $x=5$.
26. $8+3\times47$.
28. The angular magnitude about a point.
29. $800-80\div2-1$.
30. Find the width of a rectangle if the area of the rectangle increased by the width is 8, and if the area increased by the length is 14.
31. Sin 58°.
33. $(\sqrt{196})^2+3$.
34. The number of centimeters in an inch.
36. The volume of a pyramid whose base is .4 and whose height is .050.
38. The characteristic of the logarithm of 86,534,219.004237.
39. $-(15i)^2$.
41. $(7-3+1-5)\quad(68+10+3)+500=?$
43. Take two apples from three apples and what have you got?
44. The side of an equilateral triangle, whose altitude is $18\sqrt{3}$.
46. $(\sqrt[3]{85625})^3$.
48. Area of a square one of whose sides is 9.
49. A trainer plane flies to a target with the wind at a rate of 200 mph. and returns against the wind at a rate of 300 mph. What is its average rate?
51. What is the voltage of an electric current of 20 amperes if the resistance is 7.1 ohms.
52. The area of a circle whose diameter is 10.

VERTICAL

1. Volume of a sphere whose diameter is 6.
2. Logarithm of 1.682.
3. $5^x=3125$, find x.
4. $2^3\times587-4$.
5. How old is Mr. X if he is twice as old as his son, who was 12 years old two years ago?
6. The first four factors of 5^4.
7. How far will a freely falling body fall in $\frac{1}{4}$ sec?
8. Log. of 2.829.
9. $x^2+2xy+y^2=100$. If $x=2$ find y^4.
11. Thirty plus a baker's dozen.
12. $(3.66)^3$.
15. Value of pi.
17. $\frac{13^2}{2}\cdot27^{1/3}\cdot8^{2/3}\cdot\frac{1}{6^{-2}}\div10^2$.
20. An unlucky number.
23. Tan. 14°.
28. $\sqrt{x+13}+5=9$. Solve for x.
29. $x^3-3y^3-42y^2-3^6$. Evaluate this if $x=10$ and $y=2$.
30. The smaller acute angle of a right triangle whose hypotenuse is 10, and the shortest side is 2.588.
32. The perimeter of a regular octagonal hot box, 10 inches on a side.
33. Diagonal of a cube whose edge is unity.
34. The hundreds digit is the square of the tens digit. The tens digit is 5 times the units digit. The units digit is 1.
35. Subtract 5474 from the sum of all the odd numbers from 4 to 200.
37. Antilog of .85824.
40. A monkey is in a well 30 ft. deep. Each day he jumps up three feet and slides back 2 feet. How many days will it take him to get out?
42. A man has two coins worth 55 cents. One of the coins is not a nickle. What is the other one?

45. $14 more than the value, in ten years, of a $37.50 War Bond purchased today.

47. $(\sqrt{8})^4$.

48. The calibre of the famed German high powered field and anti-tank gun.

50. $(2+3-4\times5-1)\ 0=?$

52. $3\sqrt{14}\cdot\sqrt{7}\cdot 1/6\sqrt{2}$.

1	2	5	■	2	2	5	■	1	4	4
1	2	■	4	3	8	5	4	■	5	0
3	5	3	3	4	■	5	9	3	1	9
1	8	1	■	4	1	5	■	6	6	6
■	3	4	2	■	3	■	8	5	3	■
■	■	1	4	9	■	3	6	0	■	■
■	7	5	9	■	1	■	8	4	8	■
1	9	9	■	2	5	4	■	0	0	7
7	■	2	2	5	■	5	0	0	■	2
3	6	■	8	5	6	2	5	■	8	1
2	4	0	■	1	4	2	■	7	8	5

KEY TO CROSS-FIGURE PUZZLE
(Decimal points are not considered)

NEW MINIATURE ELECTRON TUBES

Miniature electron tubes recently developed here in the laboratories of the Radio Corporation of America will permit the construction of smaller home radio receiving sets and compact radio-television-record player combinations in postwar days. They are now in use in war equipment. Typical savings of 20% to 40% in equipment size will result.

The new tubes, some as small as the little finger, are a "wedding" of the acorn type tube, developed in the company's program of research in the ultra high frequency field, and the filament-type miniature tube developed in 1938. By merging the special features of the two earlier types, a combination is made of the efficient high frequency performance of the acorn with the smaller size and lower cost of the miniature. The new tube has the cathode-type inner structure of the acorn, and the small envelope and base of the filament-type miniature.

A NEW DEPARTMENT ON TRIAL

Quiz exercises, like the circus, have an appeal for persons aged 8 to 80. To satisfy this quest we are placing on trial a new department entitled *The Quiz Section*. There will be some ten or a dozen simple questions or statements, some true or false, some multiple-choice, some neither. The science involved is to be of an elementary nature, designed to arouse the interest of the younger readers. It is hoped that teachers from the grades on up will find the department pedagogically useful. Contributions are invited from all who are interested. It is especially urged that the young readers contribute. Acknowledgement will be made. Teachers are urged to try this out on their classes. Send answers and new questions to the editor of this department, ***Julius Sumner Miller, Dillard University, New Orleans 19, Louisiana.***

THE QUIZ SECTION

JULIUS SUMNER MILLER
Dillard University, New Orleans 19, Louisiana

1. The altitude of Polaris above the horizon is equal (approximately) to the latitude of the observer. (T or F)
2. In the picture showing the famous Magdeburg hemisphere experiment, two teams of eight horses each pull in opposite directions. We conclude, therefore, that it took a 16-horse pull to overcome the atmospheric force. (T or F)
3. The youngest free-living stage of an animal which changes form is termed a *larva*. Associate in proper pairs the following: tadpole, grub, fly, moth, maggot, caterpillar, frog, beetle.
4. Not all the planets revolve around the Sun in the same direction. (T or F)
5. A knot in a board is evidence that once a limb or a branch of the tree grew there. (T or F)
6. As "dead" as it looks, respiration does take place in a dry bean seed. (T or F)
7. A 3 inch ball of yarn and a 4 inch ball of yarn are wound on a 5 inch wooden ball. How thick is the layer of yarn on the wooden ball?
8. If a man 6 feet tall walked around the earth at the equator, how much farther would the top of his head move than his feet?
9. On the moon it would be possible to experience extreme changes in temperature by traveling very slight distances. (T or F)

ANSWERS TO THE QUIZ SECTION

1. T; 2. F; 3. tadpole-frog; grub-beetle; maggot-fly; caterpillar-moth; 4. F; 5. T; 6. T; 7. $\frac{1}{2}$ inch thick; 8. 12π feet; 9. T.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1903. *Howard D. Grossman, New York City; Bro. D. John, Washington, D. C.*

1911. *Paul Mount-Campbell, New Mexico Military Institute.*

1916. *M. Kirk, Media, Pa.*

1917, 9. *Roy E. Wild, somewhere in France.*

1921. *Proposed by Julius Miller, New Orleans, La.*

A chain L feet long, suspended by its upper end, is allowed to drop from its position of rest. How long does it take it to pass a point D feet below the point of suspension?

Solution by Alfred Vallée, Montreal, Canada

In a free fall motion, starting from rest, the distance travelled is given by the equation:

$$s = \tfrac{1}{2} g t^2,$$

where: s, is the distance travelled.

g, the acceleration.

t, the time taken to travel the distance s.

Then, the time taken to travel this distance can be expressed by:

$$t = \sqrt{2s/g}.$$

The time taken by the end B of the chain to travel from B to C (when the

chain begins to pass the point C) is:

$$t_1=\sqrt{\frac{2(D-L)}{g}}.$$

The time taken by the end A of the chain to travel from A to C (when the chain has finished to pass the poiint C) is:

$$t_2=\sqrt{\frac{2D}{g}}.$$

Then, the time taken by the length L of the chain to pass C is:

$$t_2-t_1=\sqrt{\frac{2D}{g}}-\sqrt{\frac{2(D-L)}{g}}.$$

$$\text{Time}=\sqrt{\frac{2}{g}}\,(\sqrt{D}-\sqrt{D-L}).$$

Solutions were also offered by A. D. M. Lewis S 1/c, Houston, Texas; M. Kirk, Media, Pa.; Clarence R. Perisho, McCook, Nebr.; and the proposer.

1922. *Proposed by Benjamin Sedlezky, Montreal, Canada.*

A baseball game may be won, lost or result in a tie. If eight games are played and one attempts to predict the results, in how many different ways can exactly six correct results be given.

Solution by A. D. M. Lewis, S 1/c

In each set of predictions there would be two games the results of each of which could be predicted incorrectly in two different ways. For instance if game 1 was actually won, it could have been predicted as either tied or lost. For each pair of games of which the results were predicted incorrectly, there are $2\times 2=4$ combinations in which the results could have been given. For the eight games there are $7+6+5+4+3+2+1=28$ different pairs of games, the results of which could have been predicted incorrectly in 4 different ways with the results of the other six games given correctly. Therefore there are $4\times 8=112$ different ways in which exactly six results could have been given.

Solutions were also offered by Clarence R. Perisho, McCook, Nebr.; Bro. Felix John, Philadelphia, Pa.; M. Kirk, Media, Pa.; and Pvt. Milton Schiffenbauer, Camp Wolters, Tex.

1923. *Proposed by Julius S. Miller, New Orleans, La.*

A juggler keeps three balls going with one hand, so that, at each instant, two balls are in the air and one is in his hand. If the time during which each ball stays in his hand is one-half second, show that each ball rises to a height of four feet.

Solution by Clarence Perisho, McCook, Nebr.

Each ball remains in his hand $\frac{1}{2}$ second, rises for $\frac{1}{4}$ second and falls for $\frac{1}{4}$ second. In $\frac{1}{4}$ second a ball will fall (or rise) $s=16(\frac{1}{4})^2=4$ feet.

Solutions were also offered by Alfred Vallée, Montreal, Canada; A. D. M. Lewis, S 1/c, Houston, Texas; Brother Felix John, Philadelphia, Pa.

1924–5. *Proposed by a Student.*

Resolve into linear factors, not necessarily real, the determinants:

(a) $\begin{vmatrix} a & b & c & d \\ b & a & d & c \\ c & d & a & b \\ d & c & b & a \end{vmatrix}$ (b) $\begin{vmatrix} a & b & c & d \\ d & a & b & c \\ c & d & a & b \\ b & c & d & a \end{vmatrix}$

Solution by Brother Felix John, Philadelphia, Pa.

With reference to determinant (a):

1. By adding together all the rows, we see that $(a+b+c+d)$ is a factor of the determinant.
2. By adding together the first and third rows and subtracting from the result the sum of the second and fourth rows, we see that $(a-b+c-d)$ is also a factor.
3. By adding together the first and fourth rows and subtracting from the result the sum of the second and third rows, we see that $(a-b-c+d)$ is also a factor.
4. By adding together the first and second rows and subtracting from the result the sum of the third and fourth rows, we see that $(a+b-c-d)$ is also a factor.
5. The remaining factor is numerical, and from a comparison of the terms involving a^4 on each side, is seen to be one.
6. Hence, $(a)=(a+b+c+d)(a-b+c-d)(a-b-c+d)(a+b-c-d)$.

With reference to determinant (b):

1. As in the solution of part (a), two factors can be shown to be $(a+b+c+d)$ and $(a-b+c-d)$.
2. Expanding (b) by minors and dividing this expansion by $(a+b+c+d)$ $(a-b+c-d)$ gives $a^2-2ac+c^2+b^2-2bd+d^2$.
3. Which can be written $(a-c)^2+(b-d)^2$.
4. Factoring, we get $(a+ib-c-id)(a-ib-c+id)$.
5. Hence, the linear factors of (b) are:

$$(a+b+c+d)(a-b+c+d)(a+ib-c-id)(a-ib-c+id).$$

Solutions were also offered by Pvt. Milton Schiffenbauer, Camp Wolters, Texas and the proposer.

1926. *Proposed by Howard D. Grossman, New York City.*

In 4-place tables $\log_{10}\log_{10}e$ differs by 10 points from its neighbors. Show that $\log_{10}(K\log_{10}e)$ differs by $10/K$ points from its neighbors.

Solution by Clarence R. Perisho, McCook, Nebr.

By use of differentials,

$$d\log_{10}x=\frac{\log_{10}e}{x}\,dx=dx$$

when $x=K\log_{10}e$.

Also when $x=K\log_{10}e$,

$$d\log_{10}x=\frac{\log_{10}e\,dx}{Kx}=\frac{dx}{K}.$$

When $dx=10$, the difference is $10/K$.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems sub-

mitted in this department. Teachers are urged to report to the Editor such solutions.

1923. *Charles McCracken, Jr., Mariemont, Ohio.*

PROBLEMS FOR SOLUTION

1939. *Proposed by Sol Whitman.*

Solve for b:

$$\frac{10}{\sqrt{400-b^2}}+\frac{10}{\sqrt{900-b^2}}=1.$$

1940. *Proposed by Rebecca Twining, East Vanick, N. Y.*

The triangle whose vertices are the ends of one oblique side of a trapezoid and the mid point of the other equals in area to half the area of trapezoid.

1941. *Proposed by J. S. Miller, New Orleans, La.*

If the earth could spin fast enough for bodies at the equator to lose their weight entirely, how long would the day be, if the earth is a sphere at all time with radius of 209×10^5 ft.

1942. *Proposed by B. Felix John, Philadelphia, Pa.*

A point, P, is inside a square $ABCD$ and not on a diagonal. If $PA=40$, $PB=50$, and $PD=30$, what is the area of the square?

1943. *Proposed by William Cox, Willard, N. Y.*

If m and n are relatively prime, show that every odd divisor of m^2+n^2 is of the form $4k+1$, k an integer.

1944. *Proposed by Grace Smith, McDuffietown, N. Y.*

Solve for x:

$$\sqrt[4]{x}+\sqrt[4]{a-x}=\sqrt[4]{R}.$$

PENICILLIN IS NOT "CURE-ALL"

A warning that penicillin is not a "cure all" is made by Francis E. Fronczak, M.D., Health Commissioner of Buffalo, N. Y.

"The public today is being misguided into thinking that penicillin, the new so-called miracle drug, is a cure for all ailments," Dr. Fronczak says. "That, of course, is not true. But dramatic reports of cures in cases of gonorrhea, syphilis, blood poisoning and pneumonia have led the thoughtless to vain conclusions.

"Penicillin in the hands of trained physicians is an important addition to the medical armamentarium, but it must not be considered a cure-all."

Meanwhile, with utmost care, makers of packaged medicines are engaged in exhaustive scientific research to bring to the public forms of penicillin which can be useful and available for over-the-counter purchase in drug stores. Now that the drug is being released generally for civilians on doctors' prescriptions, this research will be intensified.

BOOKS AND PAMPHLETS RECEIVED

DISCOVERY OF THE ELEMENTS, by Mary Elvira Weeks, Research Associate in Scientific Literature at the Kresge-Hooker Scientific Library, Wayne University. Fifth Edition. Cloth. Pages xiv+578. 15.5×23.5 cm. 1945. Journal of Chemical Education, 20th and Northampton Streets, Easton, Pa. Price $4.00.

PERMANENT LEARNING: A STUDY IN EDUCATIONAL TECHNIQUES, by W. H. Lancelot, Professor of Vocational Education, Iowa State College. Cloth. Pages x+221. 14.5×21.5 cm. 1944. John Wiley and Sons, New York, N. Y. Price $2.25.

ROCKETS AND JETS, by Herbert S. Zim. Cloth. Pages x+326. 14×21.5 cm. 1945. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.00.

THE DICE OF DESTINY, AN INTRODUCTION TO HUMAN HEREDITY AND RACIAL VARIATIONS, by David C. Rife, PhD., Associate Professor of Zoology, The Ohio State University. Cloth. 163 pages. 13×20 cm. 1945. College Book Company, 1836 North High Street, Columbus 1, Ohio. Price. $1.75.

COLLEGE ALGEBRA AND TRIGONOMETRY, A BASIC INTEGRATED COURSE, by Frederic H. Miller, Professor of Mathematics, The Cooper Union School of Engineering. Cloth. Pages xii+324. 13.5×21.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

PLANE AND SPHERICAL TRIGONOMETRY, by F. Eugene Seymour, Supervisor of Mathematics, New York State Department of Education, Albany, New York; Paul James Smith, Head of Department of Mathematics, East High School, Rochester, New York. Cloth. Pages vii+280. 14×21.5 cm. 1945. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.80.

DEMONSTRATIONS AND LABORATORY EXPERIENCES IN THE SCIENCE OF AERONAUTICS, prepared with the Cooperation of the Civil Aeronautics Administration and the American Council of Education. Cloth. Pages viii+155. 21×28 cm. 1945. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

EVOLUTION, CREATION, AND SCIENCE, by Frank Lewis Marsh, Ph.D., Professor of Biology, Union College, Lincoln, Nebraska. Cloth. 304 pages. 13×19.5 cm. 1944. Review and Herald Publishing Association, Takoma Park, Washington 12, D. C.

PSYCHOLOGY: PRINCIPLES AND APPLICATIONS, by T. L. Engle, Ph.D., Department of Psychology, Extension Division, Indiana University. Cloth. Pages ix+549. 13×19.5 cm. 1945. World Book Company. Yonkers-on-Hudson 5, N. Y. Price $2.12.

FUNDAMENTALS OF PHYSICS, by Bowen C. Dees, Ph.D., *Professor of Physics, Mississippi College*. Cloth. Pages ix+486. 13.5×20 cm. 1945. The New Home Library, The Blakiston Company, 1012 Walnut Street, Philadelphia 5, Pa. Price 69 cents.

ELEMENTARY ALGEBRA, by Edward I. Edgerton, William L. Dickinson High School, Jersey City, New Jersey; Perry A. Carpenter, West High

School, Rochester, New York. Cloth. Pages xlii+522+4. 12.5×19 cm. 1945. Allyn and Bacon, 50 Beacon Street, Boston, Mass.

INTERMEDIATE ALGEBRA, by Edward I. Edgerton, William L. Dickinson High School, Jersey City, New Jersey; Perry A. Carpenter, West High School, Rochester, New York. Cloth. Pages vi+508. 12.5×19 cm. 1945. Allyn and Bacon, 50 Beacon Street, Boston, Mass.

SCIENCE YEAR BOOK OF 1945, edited by John D. Ratcliff. Cloth. Pages xxviii+224. 14×20 cm. 1945. Doubleday, Doran and Company, 14 West 49th Street, New York 20, N. Y. Price $2.50.

FUNDAMENTALS OF ALGEBRA, Second Book, by Joseph A. Nyberg, Instructor in Mathematics, Hyde Park High School, Chicago, Ill. Cloth. Pages v+405. 13.5×18 cm. 1945. American Book Company, 88 Lexington Avenue, New York, N. Y. Price $1.60.

THE RADIO AMATEUR'S HANDBOOK, by the Headquarters Staff of the American Radio Relay League. Twenty-Second Edition. Paper. 728 pages. 16×24 cm. 1945. The American Radio Relay League, Inc., West Hartford 7, Conn. Price $1.00.

EXERCISES IN GENERAL CHEMISTRY AND QUALITATIVE ANALYSIS, by Horace G. Deming, Professor of Chemistry, University of Nebraska, and Saul B. Arenson, Professor of Inorganic Chemistry, University of Cincinnati. Fifth Edition. Paper. Pages ix+297. 18.5×25.5 cm. 1945. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.00.

SECONDARY EDUCATION AND CLEAR THINKING, by Henry Bowers, Normal School, Stratford, Ontario, Canada. Paper. 25 pages. 15×23 cm. J. M. Dent and Sons (Canada) Limited, Toronto, Can. Price 45 cents.

HANDBOOK OF CUMULATIVE RECORDS. A Report of the National Committee on Cumulative Records. Bulletin 1944, No. 5. Pages iv+104. 14×23 cm. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 20 cents.

BOOK REVIEWS

TELESCOPES AND ACCESSORIES, by George Z. Dimitroff, Ph.D., and James G. Baker, Ph.D., *of Harvard College Observatory*. Cloth. Pages v+309. 14×21.5 cm. 1945. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

This is the seventh of the Harvard Books on Astronomy. It is also one of the best for the general reader. The first chapter gives the fundamental ideas of light: waves, diffraction, interference, color, polarization, reflection, refraction, and quanta. The second tells briefly of the types of visual telescopes, describing both the reflector and refractor and the types of eyepieces. Chapter three gives the essential elements of the photographic process. Thus far the discussion is based entirely upon the fundamentals of physics and chemistry.

In chapter four the application is made of the photographic process in astronomy. Here resolution, learned in physics, takes on additional meaning, the reflector and the refractor as photographic instruments are ap-

praised and compared, the Schmidt camera and its modifications are discussed in some detail. Chapter five is the second great section of the book—Spectroscopy. First there is a brief discussion of the elements of a spectroscope, followed by a few pages on the diffraction grating. Then follows an excellent review of astronomical spectroscopy with discussions of the prism and grating and numerous diagrams and photographs showing instruments and spectra. Chapter six, on measuring light, is the third important division. Visual, photographic, and photoelectric photometry are each described in detail. Chapter seven tells the essentials of many instruments for solar research and gives a short description, with excellent photographs of the McMath-Hulbert observatory of the University of Michigan. Chapter eight, on building a telescope, gives a little of the work of amateur telescope makers but more of the work of experts and their products, including the uncompleted Mt. Palomar 200-inch reflector.

Valuable tables showing the location, size and makers of the largest reflectors, 30-inch diameters and over, and the largest refractors, 15-inch diameters and over, and of Schmidt cameras are included in the appendixes.

G. W. W.

PERMANENT LEARNING: A STUDY IN EDUCATIONAL TECHNIQUES, by W. H. Lancelot, *Professor of Vocational Education, Iowa State College*, Cloth. Pages x+221. 14.5×21.5 cm. 1944. John Wiley and Sons, New York, N. Y. Price $2.25.

This volume is an outgrowth of the *Handbook of Teaching Skills*, published in 1929. It appears to have been prepared for use as a text in teacher-training institutions. The aim, as stated in the preface, is "to produce teachers who are concerned with making knowledge functional in the lives of their pupils." The author further states that, "The book is unique in its insistence upon *teaching for permanent outcomes*, in the methods which it proposes for realizing such outcomes, in its constant emphasis upon learning by thinking, and in its demands that the thought which attends learning shall be guided as to lead to the formation of right habits of thinking by the pupils."

In the early chapters the author describes defects of current teaching practices. He points out that to achieve success the teacher must have clearly in mind the goals toward which teaching is directed. He contends that knowledge is not to be regarded as an end in education, but simply as a means to other ends which lie beyond. He names these most desirable goals, toward which the teacher should strive, as *interests*, *ideals*, *understandings*, *abilities* and *attitudes*. Several chapters are devoted to amplification of these and to techniques by which they can best be obtained.

Discussion questions and selected reading references are provided for each chapter. The last chapter includes a section on techniques making for teacher growth. The author recommends them to prospective teachers, but a review of these might be helpful to many teachers with years of experience.

The paper, printing, index, table of contents, and binding are excellent. Careful study and complete acceptance of this book would surely revolutionize teaching methods. Present-day emphasis upon mastery of subject-matter would be replaced by more effective techniques to develop exact reasoning ability, judgement, creativeness and manipulative skills which will be needed in later life situations.

Use of this text in the training of teachers should result in an improved type of teacher. The book should be excellent as a guide for study and discussion in teacher's meetings or study groups. It is recommended to

principles for that purpose. Every individual teacher, regardless of how well or how poorly trained for teaching, should find study of this volume a good investment.

RAY C. SOLIDAY

METEOROLOGY, A PRACTICAL COURSE IN WEATHER, by George J. Brands, *Chief Meteorologist, Pan American Airways System*. Cloth. Pages viii +235. 14×22.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $2.50.

The war, and its great dependence upon the weather for success, has brought the subject of the weather and weather forecasting into sharp focus, both for those who are responsible for the success of operations in the air and on the sea, and also for the average reader who wishes to understand the basis for these operations.

Many of the texts that have been the outgrowth of the war were written for the special training of technicians. They, therefore, assumed a certain amount of technical background and delved into the physics of the atmosphere at a level much beyond the ability of many interested readers to comprehend. There is much about the weather that can be taught descriptively, and many facts and principles that can be understood and applied without going too deeply into the "why." There will also be many post-war vocations and avocations such as farming, flying and sports where an ability to interpret and possibly forecast the weather conditions may prove both convenient and profitable.

It is apparently with these needs in mind that the author, who is Chief Meteorologist of one of the leading airway systems, has given in very readable form the basic materials required of the pilots, radio operators, and other flight and ground personnel of his company before entering more advanced courses on the weather required in their special fields. The book is written for self-mastery. It keeps the technical reasoning to a minimum but gives results and principles in a concise, descriptive, and practical form. Excellent self questioning exercises are given at the end of each lesson. A more general examination is given at intervals through the text.

The lessons cover the general weather elements and particularly point out their effect in the field of aviation. A history of weather forecasting contrasts the earlier interpretation of the synoptic weather map with the more modern methods of air mass analysis and principles of frontogenesis. A summary of rules of weather forecasting as evolved from these modern methods is given for general guidance. Much of the detail of codes and weather symbols found on weather maps has been omitted and would need to be supplied from some other source for those requiring its use.

The book is provided with appendices which give an excellent glossary of meteorological terms, meteorological tables, and cloud forms. The special plates showing cloud forms are made much more realistic than the usual half tone cut by showing the background of the clear sky in blue color. Of further note are the special maps, charts, and diagrams on separate sheets and folded in a pocket inside of the back cover. This allows the use of these aids at various places in the text without the awkwardness of fingering over pages.

The careful reader with but little technical knowledge should experience no great difficulty in mastering the material in this text, and from it be able to understand much of the causes, appearances, and results of the weather, and an appreciation of the problems of weather forecasting.

H. R. VOORHEES
Chicago City College, Wilson Branch

FUNDAMENTALS OF PHYSICS, by Henry Semat, Ph.D., *Associate Professor of Physics, The City College, College of the City of New York.* Cloth. Pages xii+593. 15×23 cm. 1945. Farrar and Rinehart, Inc., New York, N. Y. Price $4.00.

Since the war has practically denuded the colleges of men eligible to take the usual sophomore physics, the present demand is for college physics in the freshman year by those boys who still have a few weeks or months for training before induction into the services. Many instructors have found it necessary to alter the content of their courses for this new class of students. The results of many of these efforts have appeared on the market in the form of shorter introductory texts, in which each author has given his selection of minimum essentials, or fundamental principles, to be taught. These texts run the gamut from the descriptive type of treatise to those giving very technical treatment to selected topics.

This new text in the introductory field of physics is another teacher's selection of the fundamentals of physics based on his experience. The selection of principles here made should appeal to many instructors who have been teaching the usual sophomore college physics to technical students, but who have been forced to restrict their course. The principles principles treated are stated very concisely, but accuracy of definition and thoroughness of presentation have not been sacrificed. Principles are illustrated with solved problems and reenforced by an excellent selection of problems of graduated difficulty at the end of each chapter.

The material of this text would probably be most adaptable to those courses offering mechanics and heat in the first semester, and electricity, sound, and light in the second semester. For those wishing to give some time to modern physics, it would probably be necessary to move the subject of sound into the first semester. The presentation does not assume mathematics beyond elementary algebra. Trigonometry is used, but the essential definitions of the functions are taught early in the text. In mechanics, one might well question the advisability of deriving special equations for projectile motion at the expense of leaving out any treatise of elastic stress and strain. References to vibratory motion are very brief. The treatment of rotary motion is thorough but in a chapter by itself, so that, as suggested by the author, it may be omitted from a shortened course. The use of but two systems of units, namely, the English engineering and the c.g.s. is probably a wise limitation for introductory work. One wonders, however, if it is not high time for physics texts to put the M.K.S. system into full use and use the other metric units only as multiples or submultiples as the convenience of certain measurements may demand.

For a shortened course it would appear that too much space has been used in presenting magnetism and electrostatics. It would seem that the physicist could well follow the lead of many electrical engineers in sidestepping the confusing multiplicity of the c.g.s, electrostatic and electromagnetic systems of units, and by using the practical M.K.S. system, make a direct approach to current electricity and then bring in the necessary principles of electrostatics and magnetism where needed. This would also aid in getting essential laboratory work started earlier and with better coordination with the text.

In general the author is to be commended for an excellent choice of material and for the clearness of presentation. It is understood that no abridged selection of material will agree with the ideas of a large number of teachers, but this text should find a large use in the introductory courses where the instructor wishes to present a few topics thoroughly.

H. R. Vorhees

CHEMISTRY AND YOU, A TEXTBOOK FOR HIGH SCHOOLS, by B. S. Hopkins, *University of Illinois, Urbana, Illinois;* H. R. Smith, *Lake Forest College Lake Forest, Illinois;* R. E. Davis, *Formerly Lane Technical High School, Chicago, Illinois;* Martin V. McGill, *Howe Military School, Howe, Indiana,* and G. M. Bradbury, *Montclair High School, Montclair, New Jersey.* Cloth. Pages xiii+818. 13.5×21 cm. 1944. Lyons and Carnahan, 2500 Prairie Avenue, Chicago, Illinois.

This book is a revised edition of the authors' excellent 1939 high school text. Much of the material is the same as that included in their earlier work. The table of contents has been expanded to include not only the seventeen main units but the seventy-eight problems into which they are divided as well.

About two dozen illustrations and twenty page photographs have been revised. The appendix now includes a discussion of the Brönsted Theory of Acids and Bases and of the various ways of expressing the concentration of solutions.

The single unit, "Your Health," of the 1939 edition has been expanded to two units, "Your Health" and Your Clothing." A discussion of penicillin and the sulfa drugs is a feature of the new edition. In the unit on clothing more space is devoted to rayon and nylon, and a new problem dealing with plastics and synthetic rubber has been added.

A few of the problems throughout the text have been revised and some references to recent chemical literature introduced.

In revising the section on the octane rating of gasoline, the authors failed to revise the carry-over between pages 463 and 465 after inserting an intervening page on the knocking of gasoline. In the introductory outline of Unit XV on page 590, they failed to revise the problem numbers to account for the introduction of the new chapter on plastics.

Aside from these few minor errors and a feeling that chemical equations should be introduced earlier, there is little for this reviewer to criticize in the text. The content material is excellent and accurate. It is inclusive in character and the high school teacher will be able to select material which will suit the particular interests of his students. Teachers should find little difficulty in using both editions in the same class.

A. L. BURLINGAME

FUNDAMENTALS OF CHEMISTRY AND THEIR APPLICATIONS IN MODERN LIFE, by Monroe M. Offner, *Instructor in Chemistry, Abraham Lincoln High School, New York.* Cloth. Pages vii+408. 13.5×20 cm. 1944. The Blakiston Company, 1012 Walnut Street, Philadelphia 5, Pa.

This is one of the New Home Library series of low priced books of basic information—in this instance a survey of the field of chemistry.

The author has planned his book for readers who have not studied this science previously and for those who are familiar with the practical achievements of chemistry but do not understand how facts and theories have made great achievements possible.

The book is divided into two parts. Part One consists of a presentation of the fundamentals of chemistry. It is subdivided into three parts. Section one treats of such basic topics as physical and chemical change; elements, compounds, and mixtures; atomic theory; the periodic table; electron theory; symbols, formulas, and equations; solutions; the theory of ionization; acids, bases, and salts; and the principles of chemical reactions. Section two is devoted to a study of the non-metals and their compounds while section three deals similarly with the metals.

Part Two takes up many of the "notable contributions of chemistry to better living." Vitamins, plastics, petroleum, photography, electroplating, paints, synthetic rubber and other topics are discussed.

The style of the book is good and the material interestingly presented. Chemical principles are clearly developed. There are more than one hundred illustrations.

Results of many chemical experiments are amply described. The reader does not have to perform the experiment to understand them. The author's approach is unusual in a popular book. He consistently points out that it is chemical principles which have made practical applications possible.

A. L. BURLINGAME

SPHERICAL TRIGONOMETRY, by Aaron Freilich, *Chairman, Department of Mathematics, Lafayette High School, New York City;* Henry H. Shanholt, *Chairman, Department of Mathematics, Abraham Lincoln High School, New York City,* and Joseph Seidlin, *Director, Graduate Division, Alfred University, Alfred, New York.* Cloth. Pages III+140. 14×18.3 cm. 1943. Silver Burdett Company, 45 E. 17th St., N. Y. Price $1.28.

The authors have developed a very good "self teaching" text on spherical trigonometry. Chapter one dealing with meaning of the sphere and showing the relationship of spherical and plane triangles, great circle arcs and straight lines, is very well done. A purpose for the study of Spherical Trigonometry is presented by showing the need for it in the study of latitude and longitude, great circle sailing, nautical miles etc. Numerous problems are based upon this fact. However the later part of this chapter contains topics on spherical angles, dihedral angles, polar triangles etc. which do not fit into the trend in which the book opens. Chapters II and III cover the standard material on spherical triangles with illustrative problems worked out completely for the benefit of those who would use the text in a home study course. Chapter IV on "Applications" brings in some new uses and terms and contains a number of very good written problems. A feature of the book which adds much to its power in teaching is "Something to Think About." These items are statements or questions designed to get the student to investigate further. The book has adequate tables, answers and is fairly well illustrated.

PHILIP PEAK
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SIMPLIFIED PHYSICS, by Sidney Aylmer Small, and Charles Ramsey Clark. Cloth. Pages x+428. 12.5×18.5 cm. 1943. E. P. Dutton and Company, Inc., 286–302 Fourth Avenue, New York, N. Y. Price $3.00.

Simplified Physics is a revised edition of *The Boys Book of Physics*, of which the first printing is of date 1922. The book is, in a number of respects, unlike a standard High School Physics text in that there are no photographs, and there are no problems for the student to solve. Some diagrams as the one shown on page 161 which illustrates, "The Way Geysers Work," are on topics found generally in more advanced texts. Many diagrams appear to emphasize simplified apparatus such as might easily be made by a boy in his own laboratory. The text features some special topics such as, "The Dial Telephone," "Frequency Modulation," "The Electron Microscope," and the "Structure of Matter."

It must be apparent to the teacher of Physics that a revision of a 1922 edition would present many difficulties in view of the vast array of new developments which have come to us in the past 25 years. It is therefore

with some regret that the reviewer takes issue with the author on numerous statements found chiefly in what appear to be the new topics of the book. The following are examples of the type of physics with which the reviewer is not in accord. (1) page 279. "The current that flows in an A.C. circuit will vary but its net effectiveness will be as though a voltage of .707 E_m were on the resistance of the circuit." (2) page 279. "Inductive reactance is the opposition to A.C. caused by coils and wires near them." (3) page 142. "The small amount of actual material in the air does not hinder the radio waves when they go through the places in between the air where there is no air, possibly only that hypothetical material that the scientists call ether, the existence of which we are beginning to doubt."

There appear in the book instances in which the discussion has no apparent bearing on the topic. On page 115 is found the topic, "Where are the Sunken Ships." Under this topic the author discusses the proper selection of an oil to relieve friction on the basis of viscosity, adhesion, and cohesion.

H. H. SIEMERS
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EVOLUTION, CREATION, AND SCIENCE, by Frank L. Marsh, Ph.D., *Professor of Biology, Union College, Lincoln, Neb.* Pages 304, 13×19.5 cm. 1944. Review & Herald Publ. Assn., Washington, D. C.

This book should do much to clarify different points of view by defining the theory of creation. This theory was not correctly defined by the medieval schoolmen, by Linnaeus, nor even by Louis Agassiz. Modern creationists recognize that organisms are governed by physico-chemical laws, and that changes in organisms occur; these changes being due to the environment, recombination of characters, and mutation. Yet they claim that these observations in no way conflict with the Biblical account of creation. The author is well versed in the history of evolutionary thought, and explains how creationists believe in change within the "Genesis kind," but not in change of greater magnitude.

Dr. Marsh writes as a scientist rather than from the philosophical point of view from which similar books have been written. His weakness, however, is in the loose way in which he admits that changes have occurred, without describing a possible method of occurrence. Only a few "Genesis kinds" are supposed to have been created, for example one species of deer, and all of our present species of deer have descended from that one. But Marsh does not describe chromosomal changes that could produce the diverse characters required by the theory. A careful study of mutations would reveal that they are degenerative changes.

Whether one agrees with the author wholly or not, it will pay him to read this book. It will help him to do scientific thinking, rather than accept on authority the doctrines of nineteenth century scientists. Ample literature is cited.

WILLIAM J. TINKLE
Taylor University
Upland, Indiana

Note: The above book, *Evolution, Creation, and Science*, presents a view which is rather unusual for a man who holds a Ph.D. degree from a state university. We suggest that you also read the review by Th. Dobzhansky in the January-February 1945 issue of *The American Naturalist*.

G. W. W.

A NEW FILM CATALOG

Nearly 700 motion pictures and filmstrips produced by the U. S. Government for training and educational purposes are now available for purchase by schools, industry, and other civilian groups, it was announced today by the U. S. Office of Education, Federal Security Agency.

All of these visual aids to education are described in a new catalog which gives synopses, running time, subject groupings, and prices of the various films and filmstrips.

Subjects covered are aviation, agriculture, engineering, machine shop, nursing, shipbuilding, supervision, and many others. They range from "nuts and bolts" films, such as "Cutting a Dovetail Taper Slide," to problems in human relations such as "Employing Blind Workers in Industry," and cover such different subjects as "Celestial Navigation" and "Saving the Garden Crop."

Of the 693 visual aids now available, 440 were produced by the U. S. Office of Education as part of the Visual Aids for War Training program. Another 195 films and filmstrips, produced for military training, have been released for civilian training by the Army and Navy. The U. S. Department of Agriculture produced 58 films.

Copies of the new catalog, just off the press, may be obtained on request from the Division of Visual Aids, U. S. Office of Education, Washington 25, D. C., or from Castle Films, Inc., 30 Rockefeller Plaza, New York 20, N. Y.

NEW 7-CYLINDER ENGINE DEVELOPS 700 HORSEPOWER, USES INEXPENSIVE LOW-OCTANE FUEL

A new seven-cylinder air-cooled radial engine that develops 700 horsepower on inexpensive low-octane fuel has been announced by G. W. Vaughan, president of the Curtiss-Wright Corporation.

Known as the Cyclone 7, the new engine will permit airplane manufacturers to design short-range cargo planes and military trainer planes around a 700 horsepower installation. The new engine is similar to the nine-cylinder Curtiss engine which powers more than 80% of the nation's airlines. Close resemblance between the two makes it possible to interchange many parts, thus reducing maintenance problems.

The combustion chamber is designed for gasoline of an octane rating much lower than that of planes in the air today. Horsepower output would be correspondingly greater if higher-octane fuels were used.

The new engine is provided with a two-speed supercharger drive. The higher supercharger ratio is adequate for the development of maximum engine power at high-altitude airports. The lower supercharger ratio supplies extra power for high performance at airports situated at low altitudes.

To improve lubrication within the engine, oil jets have been provided in the crankcase to direct a continuous flow of oil into each cylinder barrel.

Education does not mean teaching people what they do not know. It means teaching them to behave as they do not behave. It is not teaching the youth the shapes of letters and the tricks of numbers, and then leaving them to turn their arithmetic to roguery, and their literature to lust. It means, on the contrary, training them into the perfect exercise and kingly continence of their bodies and souls. It is a painful, continual and difficult work to be done by kindness, by watching, by warning, by precept, and by praise, but above all—by example.

—John Ruskin.